

Transportation Engineering-Green port strategies in China

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the requirements of Edinburgh Napier
University for the degree of Master of
Research

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Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where states otherwise by reference or acknowledgment, the work presented is entirely my own.

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- i) been composed entirely by myself
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Abstract

In responding to the increasing challenges from both global climate change and local air pollution, environmental strategies are increasingly applied by ports in many developed countries, either independently by ports or as part of a national transport strategy. Their effectiveness has been successfully evidenced with significant emissions savings from the port sector, although some ports remain reluctant due to the increased costs for their users and potential loss of traffic. For developing countries, this conflict between port competitiveness and environmental protection is even sharper. Therefore, recognising that green port strategies are not “one size fits all”, the question of how to transfer successful green port strategies from developed to developing countries remains unanswered.

This thesis aims to understand the gap between developed and developing countries in green port strategy application by analysis of ports in China. China was chosen on the basis that, while still classed as a developing country, China’s rapid economic development and world-leading ports position the country as a bridge between developed and developing countries. Green port strategies already employed in developed countries are used as the basis for semi-structured interviews undertaken at two leading ports in China that are considered pioneers in their green port management.

Results show that the green port strategies applied in the ports were investment in intermodal transport connections and dry ports in the hinterland, reducing waste, dust and noise and to a lesser extent emissions of port activities and a limited application of cold ironing. This situation is similar to ports in developed countries, who also prefer to act on the issues under their control, first actions within the port and second the intermodal connections, but least motivated to take action against carriers. Future research needs to focus on how ports can incentivise greener practices by vessels in the port area and better align these to the profit motive.

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List of abbreviations

AHP	Analytic Hierarchy Process
AQMD	Air Quality Management District
ASEAN	Association of Southeast Asian Nations
CO ₂	Carbon dioxide
CRC	China Railways Corporation
DWT	Dead Water Tonnage
ECAs	Emission Control Areas
EEDI	Energy Efficiency Design Index
EFSI	European Fund for Strategic Investments
ESI	Environmental Ship Index
EU	European Union
GHG	Green House Gas
ICT	Information and Communication Technology
ITS	Intermodal Transportation System
IMO	International Maritime Organization
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MSK	Maersk Container Shipping Company
MOC	Ministry of Communication
NO _x	Nitrogen Oxide
OBOR	One Belt and One Road Initiative
OECD	Organization for Economic Co-operation and Development
PDA	Dalian Port Company Limited
PRD	Pearl River Delta
PM ₁₀	Particulate Matter 10
RTG	Rubber Tyred Gantry
SASAC	State-owned Assets Supervision and Administration Commission
SEEMP	Ship Energy Efficiency Management Plan
SOE	State Owned Enterprises
SO _x	Sulfur Oxides
SRA	State Railways Administration
TEN-T	Trans-European Network for Transportation
TEU	Twenty-foot Equivalent Unit

UK United Kingdom

UN United Nation

USA United States of America

WPCI World Port Climate Initiative

YRD Yangtze River Delta

Y-O-Y Year Over Year

Publications

Edinburgh Napier University regulations state that any publications resulting from the research undertaken for this thesis must be noted. The results of this thesis have been published in the following book chapter:

- Du, K., Monios, J., Wang, Y. (2019). Green port strategies in China. In: Bergqvist, R., Monios, J. (Eds). *Green Ports; Inland and Seaside Sustainable Transportation Strategies*. Elsevier: Cambridge, MA.

Fully text could be found in the Appendix.

1. Introduction

1.1 Research motivation and objective

Maritime transport is the backbone of the increasingly globalized economy and international trade system. However, greenhouse gases and other emissions from vessels and related activities in maritime trade have caused significant environmental impacts, especially in coastal areas (Smith et al., 2014). As the functions undertaken by ports have expanded significantly from just the handling of ships and cargo to the pursuit of a wide range of interests (Gibbs, 2014), local pollution as well as climate change aggravated by greenhouse gas emissions from the port area are now receiving more attention. Yet it remains difficult to harmonize economic activities and environmental considerations both in seaborne trade and within the port.

It was in 1992 that the UN defined the concept of environmental sustainable development, but the notion of “green ports” has become more familiar only in recent years, as it is recognised that seaports need to significantly reduce emissions of existing and future activities in the port areas and the wider logistics area (Lam and Notteboom, 2014). At the same time, ports must not only focus on emission reduction and more environmental practices, but also retain a focus on port growth (Fahimnia, 2015). Thus, a green port strategy should fulfil both economic and environmental objectives, leading to sustainable development. Therefore, the port’s role is to blend corporate social responsibility, port strategy and the need to implement national and local environmental regulations. Although ports may not always be legally required to enact certain strategies through enforced regulations, they could benefit from the associated tools of problem mapping, action and management planning. Some main hub ports in Europe and America have already adopted their own green port strategies. However, owing to variable pollutant targets, operational conditions, terminal type and configuration in each port, there is no ‘one size fits all’ approach for all ports and each measure needs to be analysed on a case-by-case basis. Furthermore, few cases in the academic literature have focused on developing countries in which the conflicts between economic development and environmental protection are increasingly sharp.

Therefore, the motivation for this research is to transfer the framework of port management from developed to developing countries. Although China is still classed as a developing country, its rapid economic development and world-leading ports position the country as a bridge between developed and developing countries and therefore makes an appropriate case selection. Some studies have analysed the main environmental goals and concerns of Chinese port stakeholders, but this thesis takes a more strategic focus, first by exploring what strategies have actually been implemented, and then splitting them into ship emissions, port activities and hinterland transport. Finally, the use of semi-structured interviews enables the possibility to understand the motivations and challenges related to each green strategy. The central research questions for this thesis are: What green port tools have Chinese ports employed to achieve their sustainable development? What did the ports active and reluctant to do? Why did the same green port tools encounter different situations in two ports? This research could be a preliminary step for exploring Chinese green port management from a policy perspective in the future and the results could be a useful reference for further depth researches about China.

Chinese government has started its first step following international regulations and experiences from developed countries in green port management. As each country has different political background, resists may arise during the implementation process if Chinese government just repeat the experiences obtained from other developed countries.

However, only little studies have addressed the situation in China. The objective of this research is to find out real condition of China's green port management. By comparing the factual information of green port tools implementation situation in China with other developed countries', the gap in between could be more clearly spotted. In the end, scenario building is introduced to discuss the possible policy environments for green port management in China hence to give out future working direction for China's green port construction manager to narrow the gap in the next stage.

This paper aims to be the preliminary step for exploring Chinese green port management from a policy perspective, to enrich the experiences for Chinese state and local policy maker in future strategy planning hence to accelerate green port construction in China. Moreover, this research is also going to provide the first-hand information for green port

management researchers in the world who especially focus on developing countries and take China as cases.

1.2 Methodology

To investigate the green port tools that Chinese ports employed to achieve their sustainable development following the understanding of literature reviews of developed countries underlying this research come from the interpretive viewpoint which suggests the need for research using qualitative methodology. The interpretive approach operates under the assumption that access to reality is only possible through social constructions such as language and shared meanings (Valsiner, 2005).

The research strategy adopted in this thesis was to conduct two case studies in two ports which are representative in China's green port management. The fieldwork was conducted at the sites during the periods from August to September, 2017. The main qualitative data collection method was semi-structured interviews with the top managers in the case company, and the goal was to get a more in-depth study by using this method.

Although the costs of interview are relatively high and more difficult to collect scalable data than questionnaires, it has a 'deeper' understanding of social phenomena especially when little is known about the study phenomenon or where detailed insights are required from individual participants. They are also particularly suitable for exploring sensitive topics, where participants may not want to talk about such issues in a group environment. In this research, semi-structured face to face interviews are employed as the status of green port development in China is not known thoroughly by the world and richer data are required for further investigation. The whole process of the interview is based on the question and answer conversation where the researchers could modify their questions during the interaction within the conversation. This kind of interview mainly draws on 'what' and 'why' questions instead of 'how much' or 'how many' so that there should not be assumed answers nor predetermined boundaries as to the topic during the interview. Some scholars argue this flexibility can be a limitation, because the researcher may consciously or subconsciously influence the directions of the conversations and affect the responses from their interviewees, thus reflexivity and the narrative of positionality become indispensable in the interview.

1.3 Impact and relevance of the findings

By comparing green port strategies adopted in developed countries with the results gathered from the two Chinese ports, it appears that Chinese ports (at least in these two cases) are actively improving the environmental performance of their activities inside the port in terms of waste, dust, noise, etc. but less so in terms of emissions reduction. They are both starting to work actively in the hinterland transport sector, while doing little in terms of incentivising action on ship emissions. While on one hand, it shows that Chinese ports still have work to do in order to be consistent with national macro-policies promoting a transformation from fossil energy-intensive developments to sustainable development over the past 10 years, on the other hand these findings are consistent with the actions of many world ports.

The main conclusions show that, firstly, the lack of green port tools implemented for reducing ship emissions, is the reluctance to introduce charges for polluting ships or financial incentives for more environmentally friendly vessels. This might also reflect to some extent the limitation of the Chinese political context. Secondly, the active of ports to dealing with waste, noise and dust, as well as plans for monitoring the local ecosystem indicates they are easier to achieve with lower investment as these are extensions of daily activities already happening at the port. Thirdly the greater interest by the ports on hinterland transport strategies can be explained as a result of the policy Chinese national plan. This could reflect that the national plan has large transformation impact on the industry chain of the enterprises. The active involvement of ports in dry ports in recent years suggests some moves towards improving the inland movement of containers via increased integration between the ports, rail operators and inland terminal developers. This is a case where commercial objectives match environmental goals, in this case introducing measures to increase the capacity to and from the port, but more work is needed on the organisational processes to develop the Chinese intermodal network towards the models adopted in the USA and Europe (Monios and Wang, 2013). Fourth, different geographical backgrounds between the two ports have also influenced the varying logistics practices in each port.

The gap between developed and developing countries in green port strategy application by ports in China is analysed by this study. All the findings showed that developing countries are setting their first steps towards green port management strategies, however, the progress is slow.

1.4 Structure of the thesis

The structure of this thesis is as follows. Chapter 1 is focusing on the introduction, motivation and purpose of the research, methodology employed and the impact and relevance of findings. Chapter 2 will be giving a literature review of the background of research question including what does green port mean and what have been done by previous researchers on it, what are the green port tools that have been adopted in developed countries. In Chapter 3 the methodology and research method are given. Firstly, reviewed the research methods used by previous researchers in this field. Then introduce the method chosen in this thesis which is a case study. After that the preliminary work on how to design case study, how to select the cases, and the way that the data were collected and analysed are interpreted.

Chapter 4 will be presenting the overview of China's port system and then followed by its green port policy and strategy. Then Chapter 5 which focuses on case studies of two Chinese ports, the information of Ningbo Port and Dalian Port will be illustrated. Chapter 6 will present the results, analysis and discussion of the case studies. The last Chapter 7 is the conclusion includes research summary, contribution to the literature, reflection on the methodology and limitation, and finally suggestions for future research.

2. Literature Review

2.1 Introduction

In this chapter, the environmental impacts in ports will be analysed first in 2.2. After that the green port concept will be interpreted in detail in 2.3 which is followed by 2.4, the green port tools in shipping emissions, port activity and inland transport system. Then in 2.5 comes the conclusion.

2.2 Environmental impacts in ports

Though shipping is the pillar in ports' economic activities and important role steering economic development in port vicinity areas, the environmental impacts on these places are hard to quantify. GHG and pollutant emissions could be drawn from fuel consumption during the sailing while the drawbacks from in-port marine activities on ecological system and human living require more complex evaluate procedures. Port sector that provides the management at national interface between territory and territorial water are expected as a problem solver.

According to several scholars (Boscarato, 2015; Bergqvist, 2012; Chiu, 2014; Dalsøren, 2009; Duffy, 2011; Genovese, 2016), environmental problems usually affecting ports are air pollution (smog, dust, odor, Sox, NOx, ship exhausts), greenhouse gas emission, noise and light pollution (congestion), waste water discharges (ballast water and sewage), solid and hazardous waste generation, soil degradation and erosion. In a project directed by OECD, it classifies the problems into three subcategories (Oecd.org., 2017):

- (1) problems caused by port's activity
- (2) problems caused at sea by ships calling at the port
- (3) emissions from inter-modal transport networks serving the port hinterland

These can be more split in following table with the environmental concerns caused by each one and their severity ratio. It can be seen from Table 2.1 that it is 'in the port area' generates most severity results when comparing to other two regions.

Table 2.1 The severity of environmental impacts from three main sectors in port area

Environmental concern	In the port area	At sea	In the hinterland
Exhausts of NO _x	xx	xxx	xx
Exhausts of SO _x	xx	xxx	x
Exhausts of particles	xxx	xx	xx
Energy use and emissions of CO ₂	xx	xxx	xxx
Emissions of other greenhouse gases	x	xx	xx
Noise emissions	xxx	-	-
Ballast water handling	xxx	xxx	-
Oil spill	xx	xxx	-
Disposal of sludge and other types of oily waste	xxx	-	-
Disposal of sewage	xxx	xx	-
Disposal of garbage	xxx	-	-
Snow and rain water removal	x	-	-
Dust prevention	xx	-	-
Handling of hazardous cargo	xx	xx	xxx
Use of anti-fouling paints	xxx	xx	-
Dredging and contaminated soils	xxx	-	-
Land-use and resource conservation	xxx	-	x

xxx: large impact xx: medium impact x: minor impact

Source: adapted from Oecd.org. (2017)

When it comes to the negative influences of near-coastal shipping on port areas, firstly, in-port activities such as goods handling, truck operation lead to noise pollution. Ferries, ships, industrial and shipyards are the main sources where noise comes from. Long time exposure under noise could cause hearing and cardiovascular troubles with high blood pressure, mental stress and lack of concentration as incidental drawbacks. Ballast water is to keep the balance of ship under sail but it is associated with a serious threat to marine biodiversity and coastal ecosystem. The handling of ballast water steer the coastal ecosystem: the invasive species or pathogens carries by that has been considered as one of the most dangerous environmental hazards (IMO.org., 2016); Misaligned inspection

bring about insects get into all sorts of places such as poisonous spider from Australia, giant African snails and red fire ants that turning up in containers can attack in a swarm with potentially fatal consequences for wildlife, animals and even young children. Water quality is an indicator which provides basic information on the health of marine waters and their ability to support the diverse habitats and the wide array of marine species that live in the marine environment (Duffy, 2011). Waste discharged in port such as oil, sewage, garbage, ballast water and contaminated dredged material from ships and boats also require well conduction from port. Then, in port expansion programme, dredging offers essential services including create artificial wetlands. In return, wetlands, coral reefs and oyster beds that work as flood protector are vulnerable. Finally, dust in port that released from transport of material and handling of bulk cargo cultivates the risk of spontaneous combustion for fire. This is extremely dangerous in hazardous cargo terminal.

Secondly ship-generated emissions are generally the main source of air pollution especially particulate matter. Pollutant gasses both from ships calling at the port impact human health and marine fishery resources in coastal area. From the picture in the report 'Seaports of the Americas' (Eia.gov., 2017), in 2004, Port of Los Angeles generated largest ratio of NO_x and PM₁₀ emission per day. Over 30 human epidemiological studies reveal that diesel exhaust increases cancer risks. Children living near busy traffic hubs are more likely to suffer from decreased lung function, wheezing and bronchitis. What is more, nitrogen dissolved in water could either acidification water areas or aggravates the climate change. That is why water quality monitoring becomes a hot topic in biochemical research areas. Besides of that, according to figures from the Los Angeles Air Quality Management District (AQMD) (Schneider Electric Blog, 2013), 700 people were dead from berthed ship emissions every year. In China, haze plagues main land residents especially in recent years which have cracked a similar situation happened 60 years ago in London during the period of Industrial Revolution. The increasing number of ports and ships induce air pollution on local and regional areas. Measuring by ship emission factors that used by the Entec UK Limited database, ship emission in Pearl River Delta, Yangtze River Delta and Bohai-Rim area are most serious (Zhang, 2017). Hence, emission and noise levels standards to ensure natural and urban sustainability and high level of life quality in surrounding territories should put prior in port management.

Thirdly, in-land transport and inter-modal trading give out environmental impacts on ports too. From the research modal in report of OECD, trucks generate the largest amount of air pollution emission factors in road freight transportation (Oecd.org., 2017). Diesel driven vehicles that distribute cargos from port to hinterlands causes a considerable air, noise and congestion nuisance. Transport network in city region especially metropolis is facing capacity problems. Comparing with high gathers and distribute flexibility, substitute ways like rail and barge freight lost their competitiveness even further. In fact, trains consume three times less energy than cars to transport the same number of people on average, and what is more, trains use six times less energy than trucks and emit only one-fifth the amount of carbon dioxide (Voxeu.org., 2007). Consequently, in order to improve energy efficiency and mitigate road heavy traffic flow, on the one hand, noise, speed and emission limitation standards are being put forward. Pricing system that engenders competition between different means of transport is required on the other hand. Green port dues including road fee that internalize external costs are waiting for further researching.

2.3 The green port concept

Environmental port management is becoming an essential activity in port cities (Klopott, 2013), and also, they are becoming important players in regulating and reducing the carbon footprint of vessels entering, leaving and calling at them. Green development first comes out as a real estate development concept (Wilson, 1998) consists of environmental responsiveness, resource efficiency and community and cultural sensitivity. Green development has emerged as a solution to tackle the environmental pollution coming from construction and operation of a port (Chiu, 2014). Fahimnia (2015) asserts besides of emission reducing and reactive environmentally friendly, port growth in a more proactive focus is vital. A green port strategy should fulfil both economic and environmental objectives to lead a sustainable development (Pavlic, 2014). However, when compared to road transport, there is not much known about the carbon footprint of maritime transport. From the Paris Climate Agreement in Oct. 2016 which provides a new global goal to hold temperature increase below 2 degree during the conference hosted in Marrakesh. The two parts that will witness the most significant emission increasing speed by 2050, aviation and maritime transport are not covered (IMO.org., 2016). The main reason behind this is

there is no universal accepted standard to reconcile various positions and address disproportionate impacts on certain countries (Imers.org., 2016). Therefore, promoting green port management could help to define the role that international shipping sector plays in GHG emission.

Apart from using fewer resources to conserve energy and minimizing damage to ecosystem, green ports are expected and responsible for conducting vessels subject to closer scrutiny in terms of ships, shipping, greenhouse gas emission control, carbon emission, air pollution and oil spill related environmental impacts (Davarzani, 2016). Geographically speaking, port is the place in advocating the promotion and implementation of conventions as a supplementary of national and local government regulations which means the green ports also requires improved political structure, official responsibility distribution or governance decentralization. Legislations aimed at protecting the environment associated with operation and management of port facilities and marine transportation companies are now well established in European sea ports (Walker, 2016). The European Commission (EC) defined the energy priorities for the next ten years and set the actions to be taken for lower greenhouse gas emission and energy consumption (Climate, 2016). Whilst, the European Sea Ports Organization (ESPO) which represents sea ports in the maritime states of the European Union was created for better policy making. More proactive approaches that port authority adopts the more sustainable development port could be coined. Moreover, improve the competitive position of the port and release the climate change pressure in the end.

Here, it has been realized that ports and port areas are the only parts to promote green concept into action. Despite of the importance of the topic the literatures are limited. Most of researches are focusing on regulations at ship operation phase, such as verify the new standard for vessel that could make shipping more environmentally friendly (IMO.org., 2016; MacIsaac, 2016; Psaraftis, 2010), or choosing alternative routes that diminish the influence of ocean surroundings (Prpić-Oršić, 2016). The technology issue in terms of generator and auxiliary engine retrofit, more efficient ship hulls and propulsion (Eide, 2009; Perera, 2016; Geng, 2016; Dedes, 2016; Ling-Chin, 2016). External control like 'cold ironing' in ports that provide electrical supply to ship from shore sources, sulphur, nitric oxide remover devices such as scrubbers (Boscarato, 2015) are published but only

from technical angle. Other logistics-based measures involve speed optimization, routing design, fleet planning and supply chain management from the in-port design perspective to reduce maritime greenhouse gas (Fahimnia, 2015; Genovese, 2016). Finally, water quality monitoring of ports' environment on the basis of biological parameters add objectively procedure and guideline for implementing (Wooldridge, 1999). Methods for ship to perform green are gradually clear from the researches mentioned above and doubtlessly technical innovation and infrastructure design reform are efficient way to achieve the goal of sustainability, however, how to achieve the success by horizontal enablers such as port authority and local government, there is a short of articles to follow.

Green port strategy is basically an examined way for port to tackle environmental problems come from three part described in the previous section from a management view. Owing to different political system and port background, port management is a complex process that varies from port to port and country to country. From the beginning, green port concept are mainly focused on energy efficiency (Acciaro, 2014), environmental affects (Chiu, 2014; Walker, 2016) and related service and supply chain management (Ng, 2013; Klopott, 2013). In the latest decade, port authority, management and operations of green ports attract higher attention. Some authors are interesting in economic statistics (Dalsøren, 2009; Tesfay, 2014), research that regarding the balance between economic and environmental performance (Psaraftis, 2010). Wan et al. (2018) developed a quantitative model for evaluating green port developments. Operational options for ports strategic issues (Mateo-Mantecón, 2011; Gibbs, 2014; Sys, 2016), contribution to the identification of the value added that environmental performance might bring to ports (Acciaro, 2014) are all mainly focus on developed and advanced ports. For example, Winnes (2015) in his research on port of Gothenburg anticipates CO2 emission till 2030 and three scenario measures on ship. There are much already publications on emission reduction methods, responsibility within ports. Indeed, when it comes to execution, no rounded system for each port based initiative because of varies of port's status. A critically tested and systematized procedure can add objectively to an area of concern usually dominated by emotion and subjectivity (Wooldridge, 1999). Thus, a backward port or new green port practitioners need a holistic deployment for themselves' management prior. Up to now, only the article of Lam and Notteboom (2014) has comparing the port management tolls by leading ports in Asia and Europe, lists out the policies' effectiveness

in them. This encourages other ports that need upgrading their green port innovations to formulate the framework of advanced ones.

In the paper of Lam and Notteboom (2014), the authors choose four world-classed ports including Singapore, Shanghai, Rotterdam and Antwerp. Their study shows that these ports have taken measures to show their environmental concerns and responsibility in taking care, and have started to implement the concept of sustainability. The authors classify various policies and tools into three main categories, pricing, monitoring and measuring, and market access control and environmental standard regulation.

However, they focus more on the effectiveness of green port tools in the four ports but give limited discussion on the reason behind less effective one in the implementation process. Moreover, their research compares Chinese port with other 3 worldwide ports from literature review, which could be hard to understand for the readers who are not familiar with China's background as there are limited references. In my research, I will try to find the reason behind the less effective tools through face to face interview to give more completed information of China.

As Lam and Notteboom (2014) has listed relatively completed green port tools in four world-classed ports, I designed my interview questions basically on the summarization of them, but further classify into ship emissions, port activities and hinterland transport. The classification is according to the source of GHGs emission and pollutants that causing environmental problems in port which has been adopted in the project directed by (Oecd.org., 2017). Also, it has been summarized in the book 'Report on Changjiang River Shipping Development in 2017' wrote by Ministry of Transport of China in terms of 'promote the use of green vessels', 'prevent and control pollution at ports' and 'innovate the mode of transportation'. The criteria that is going to be used to assess 'greenness' adopted in my research are derived from experiences in green ports that are summarized in Table 2.2, 2.3 and 2.4.

Instead of selecting ports from different country, I focus my research on two Chinese ports with one in north and one in the middle. In this way, a more specific picture on overall Chinese green port management situation can preliminary be drawn.

Moreover, the use of semi-structured interviews is another difference. This enable the possibility to understand the motivations and challenges related to each green port tool. In the analysis procedure, the SWOT analysis has been employed to draw the overall landscape of green port strategies in case ports in terms of strengths, weaknesses, opportunities and threats in the fields of ship emission, port activities and port hinterland transport. The same characteristics from two cases can reflect good experiences in green port management, which can be used for greening other ports in China in the future. Besides, the aliened ones from each port should raise attention of state strategy makers to find suitable measures for similar cases in the future.

The reasons behind the less effective tools should reflect bottleneck in promoting green port management in China and deserve more analysis. The classification that I employed here could be more generalized and suitable to link my research in China to international researches because it was employed by both Ministry of Transport of China and OECD. Then, I use semi-structured interview instead of exploratory and comparative review in order to provide more depth analyzation and factual information. The selected cases are for better understanding of China rather than other countries.

2.4 Green port tools

This section discusses the available green port tools according to the three-way distinction of the OECD into ship activities, port activities, and hinterland transport. The tools have also been examined in some world-classed ports so that they could be the benchmarks for China's ports. The information about the ports listed in Table 2.2 to 2.4 are collected from the ports' official websites, the port annual reports and relative researches.

2.4.1 Shipping emissions

Environmental damage in the maritime sector is addressed by the MARPOL conventions developed by the International Maritime Organization (IMO). These conventions, updated over time, cover various maritime pollution issues such as emissions, oil spills and ballast water (Lister et al., 2015). Since 2008, the IMO defined Emission Control Areas (ECAs) with limits of 0.1% Sulphur, and a global sulphur limit of 0.5% will be in force from 2020, reduced from the current limit of 3.5%. NO_x is addressed through limits

on new vessels, the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP). There is as yet no global CO₂ limit enforced by the IMO. These enforced conventions have led to new research fields for ship emission controls, such as verifying the new standard for vessels that could make shipping more environmentally friendly (Psaraftis and Kontovas, 2010), or choosing alternative routes (Prpić-Oršić, 2016). Technology issues include auxiliary engine retrofit, more efficient ship hulls and propulsion upgrading (Eide, 2009; Geng, 2016; Ling-Chin, 2016). All of these items evidence a growing trend in more environmentally friendly ships. However, higher environmental requirements may affect the interests of ship-owners due to the higher costs of retrofit demands.

A number of port authorities are beginning to provide incentives for greener vessels. For example, the World Port Climate Initiative (WPCI) is a group of 55 ports worldwide that pursue various green measures such as giving discounts to vessels scoring above a certain threshold on the Environmental Ship Index (ESI). Some large ports in the USA are taking independent action, for example, the Port of Long Beach launched a voluntary program, the 'Green flag incentive' which provided discounts for port dues on incoming ships reducing their speed in the port area (Ahl et al., 2017), which is one of the main strategies available to ports to reduce emissions from vessels (Winnes et al., 2015). Also, in 1st January, 2017, the At-Berth Regulation makes it compulsory that all vessels calling at Californian ports should use shore-based electrical power to reduce emissions.

EU Port policy promotes the charging of environmental costs by seaports. The port of Rotterdam is one of the 30 core European ports who already apply green charges to use their infrastructure. It developed Green Award discounts for ships according to their environmental performance to incentivise ships to reduce their pollutant emissions; ships with a valid Green Award certificate could enjoy 10 to 20% discount of its port fees. As well as these, to facilitate investments in green port infrastructure the EU Commission can provide financial support for fixed, mobile or offshore port infrastructure allowing a port to supply vessels with energy sources such as electricity, hydrogen, or Liquefied Natural Gas (LNG). The European Investment Bank and the European Fund for Strategic Investments (EFSI) created a €750 million EFSI Green Shipping Guarantee Programme open for both retrofitting of existing ships as well as for the construction of new vessels

with a green innovation aspect. Various EU research and funding programmes are also available to help Member States to implement alternative fuel infrastructure which contributes to the decarbonisation of transport and enhance the environmental performance of the maritime sector.

Looking in other parts of the world such as Asia, poor collaboration with shipping companies and other members in the supply chain were listed as major challenges in Association of Southeast Asian Nations (ASEAN) ports' sustainable development (Roh, 2016). The authors found little attention towards providing incentives to shipping companies to use clean-burning low sulphur fuel, reduce speed while near the port and adopt environmentally friendly vessel designs. Some studies have explored the potential for green port policies in Asian ports such as slow steaming but little research has been done on current application of policies.

A list of some of the main shipping emission strategies taken by ports is presented in Table 2.2.

Table 2.2 Green port strategies for ship emissions

Green port strategies	Port example
Penalty or incentive based on green performance of vessels (e.g. ESI, EEDI)	Port of Oakland, Port of New York, Port of Georgia, Port of New Jersey, Port of Seattle, Port of Gothenburg. Port of Amsterdam.
Require slow steaming while on approach or in the port	Port of Rotterdam, port of Antwerp, Port of Singapore, Port of Gothenburgh
On-shore power supply	Port of Vancouver, Port of Gothenburg, Port of Rotterdam, Port of Zeebrugge, Port of Lubeck, Port of Los Angeles, Port of Long Beach. Port of Kotka, Port of Kemi, Port of Oulu. Port of Stockholm.

2.4.2 Port activity

Some of the main green strategies for port activities include reducing energy use in ports by using cleaner power (electric or LNG) vehicles in port activities and developing renewable energy sources in the port (Acciaro et al., 2014). Other possible strategies include plans for waste management and recycling, including sewage, spills and ballast water, reducing noise, vibration and dust from handling activities (Lam and Notteboom, 2014) and ecosystem protection relating to the marine habitat, wetland and coastal erosion (Chen and Pak, 2017). Examples of such strategies can be found in the ability of cranes to store the energy released when lowering a container, or in the use of LNG-powered trucks in the port area (Hu et al., 2017). The port of Los Angeles has been using new and cleaner-burning equipment to reduce emissions from cargo handling equipment. The Port of Rotterdam encourages port-based companies to report their carbon footprint through using renewable energy and fuel saving measures to reduce CO₂. In addition, smart port management can also combine measures to reduce emissions, energy consumption and costs by minimising ship idling time, optimising the landside operations of calls, using digital technologies to facilitate logistics processes, developing innovative mobility concepts, renewable energies and the interlinking of power plants and consumer plants to promote efficient use of resources.

In developing countries, challenges result primarily from the high cost of implementing green policies. Kegalj and Traven (2017) discussed the possibility of implementing an on-shore power supply system in Croatia, but found that a lack of infrastructure and the high installation costs were prohibitive. In other cases, the challenges relate more to institutional and governance issues. Klopott (2013) showed that ports in Poland have complied with EU regulations since joining the EU in 2004, and have active environmental management in place, including monitoring their emissions and water quality, and some investments towards technological solutions. However, they still mostly follow the EU requirements rather than pushing beyond that level. Barnes-Dabban et al. (2017) explored the contextual influence of institutions in sense-making for ports adapting the ‘green port’ phenomenon in West and Central Africa. The paper showed that since the port authority underwent institutional restructuring from a service port to a landlord port with increased private sector participation, the flexible and adaptable bureaucratic approaches and a communicative and consultative organization culture helped to turn the ‘green port’ phenomenon into business reality.

A list of some of the main port activity strategies taken by ports is presented in Table 2.3.

Table 2.3 Green port strategies for port activities

Green port strategies	Port example
Using cleaner power (electric or LNG) vehicles in port activities	Port of Rotterdam, Port of Los Angeles, Port of Long Beach, Port of New York and New Jersey, Port of California, Port of Singapore.
Developing renewable energy source in the port	Port of Rotterdam, Port of New York and New Jersey, Port of Los Angeles, Port of Long Beach, Port of Singapore.
Waste management and recycling, including sewage, spills and ballast water	Port of Los Angeles, Port of Long Beach, Port of Rotterdam, Port of Vancouver, Port of Newport, Port of Busan, Ports of Portland, Port of New York and New Jersey, Port of Stockholm, Port of Gothenburg.
Noise and vibration reduction in handling activities	Port of Los Angeles, Port of Long Beach, Port of Amsterdam, Port of Auckland, Port of Rotterdam, Ports of Vancouver, Port of Busan.
Dust control from bulk handling	Port of Queensland, Port of Rotterdam, Port of Vancouver.
Ecosystem protection (marine habitat, wetland and coastal erosion)	Port of Auckland, Port Los Angeles, Port of Long Beach, Port of Rotterdam, Port of Vancouver.

2.4.3 Inland transport system

In recent decades, several papers on CO₂ and other external cost savings by modal shift on port-inland links have been published (see Lam and Gu [2013] for a detailed review). For example, Janic (2007) developed a generic external cost formulation for intermodal rail and road transport in terms of air pollution, noise, traffic accidents and congestion, while Janic and Vleugel (2012) showed the mitigation of externalities (greenhouse gases, noise, traffic accidents and congestion) on real-life cases. Sanchez Rodrigues et al. (2015) demonstrated that rerouting of containers away from traditional large ports in southeast UK could significantly reduce the overall CO₂ emissions, but indicated that to achieve this goal would require more vertically integrated supply chain to smooth the flow of container movement between ports and inland origins.

Very few papers have directly studied the role of ports in incentivising greener hinterland transport. Bergqvist and Egels-Zandén (2012) investigated the use of port dues to encourage shippers to send their cargo to/from the port by rail, and Bergqvist et al. (2015) performed a multi-actor multi-criteria analysis of the views of several port stakeholder groups on potential green hinterland actions, finding that road pricing and port dues were the most popular overall. Gonzalez-Aregall et al. (2018) reviewed a global set of ports and found that 76 out of 365 world ports were applying some form of green port hinterland strategy. They found that the most common green hinterland goal of these ports was to reduce air emissions, which was usually done through monitoring programmes. Land congestion and modal shift also scored highly as goals, but dealing with noise in hinterland transport was much lower priority. The most popular measure for reducing land congestion was improved technology while the top measure to achieve modal shift was investing in infrastructure. Some ports are world leaders in green port strategies in both seaside and landside. The clean truck program at the port of Long Beach modernized the port trucking industry and mitigated truck-related air pollution since 2007 (Giuliano and O'Brien, 2008). The port of Rotterdam has been unique in implementing a modal shift obligation in their concession agreements with port terminal operators (Van den Berg and DeLangen, 2014).

Incentives and regulations have been put into force by policymakers in some regions to reduce barriers to increased modal shift in port hinterlands. In the EU, for example, ports can get funds from targeted grants and other programmes to improve port infrastructure, rail and inland waterways connecting to ports if it can be shown to lead to a modal shift. The Trans-European Network for Transportation (TEN-T) was developed as the backbone of European transport infrastructure planning with a focus on intermodal corridors within Europe.

When it comes to the greening of port-inland transportation in developing countries, little research has been undertaken to date directly on the port's role, although there has been some research on intermodal corridors. For example, Regmi and Hanaoka (2013) assessed the potential for emissions reduction through modal shift on corridors between Laos and Thailand. Gonzalez-Aregall et al. (2018) showed in their global review that very few ports in developing countries are taking action to improve environmental activities

in their hinterland. Thus, any moves towards reducing emissions from inland transport are a result of modal shift from road to rail, which is driven by national government's institutional reform of rail operations and investment in rail infrastructure and capacity, leading to a higher quality of rail services. Sometimes, ports have a role in this activity via competitive moves to develop dry ports, which have been observed in China (Monios and Wang, 2013; Beresford et al., 2012) and other Asian countries (Hanaoka and Regmi, 2011; Ng and Cetin, 2012).

A list of some of the main green hinterland strategies taken by ports is presented in Table 2.4.

Table 2.4 List of green port strategies for the hinterland

Green port strategies	Port example
Give discount on port dues and fees for shippers based on choice of modal shift	Port of Amsterdam, Port of Rotterdam, Port of Stockholm
Incentives and licensing for greener trucks	Port of Long Beach, Port of Los Angeles, Georgia Ports Authority, Port of Baltimore
Invest in hinterland infrastructure	Port of Amsterdam, Port of Rotterdam, Port of Los Angeles, Port of Gothenburg, Port of Hamburg
Collaboration with rail operators to develop intermodal services	Port of Rotterdam, Port of Gothenburg, Port of Antwerp, Port of Zeebrugge
Invest in dry ports	Port of Charleston, Port of Genoa, Port of Rotterdam, port of Gothenburg

More source may refer to: Nguyen, C L and Notteboom, T. (2016); Inboundlogistics.com. (2018); Metrans.org. (2015).

2.5 Conclusion

Earlier in this chapter, environmental problems caused by maritime transportation are summarized at the beginning based on literature review. All the evidences shown emission and other concerns had arouse more concerns from the public indeed. Measures to tackle with these problems in terms of technical innovation, policy making and management are under the investigation of researchers from all background. After that, the idea of green port management is introduced as one choice to mitigate the environmental impacts generated by international or national shipping transportation and also, the application of green port management in some prior ports prove the effectiveness on energy saving and emission reduction. Therefore, how to smooth the managing process

and achieve a wider application in world's ports then become a new research direction. Ports in some developing countries that operate busy international trade are required to work harder on decarbonization as they consist large part of global greenhouse gas emission.

3. Methodology

3.1 Introduction

This chapter is about the procedures used in this study, in regard of the research method and data collection. After examining the methods employed in previous research by formally drawing this out of the literature review, this is an important part of shaping how research should be undertaken in the current study and also develop the criteria for selecting the case studies. This chapter also discusses the validity, reliability and research ethics appropriate to the study. The structure of Chapter 3 is as following. 3.2 The research methods used by previous researchers in this field will be summerized in Table 3.1. Then will focus on interview method 3.3 Utilization of qualitative methodologies; 3.4 Case study design; 3.5 Case selection in this study; 3.6 Data collection process; 3.7 Data analysis; 3.8 Validity and reliability; 3.9 Research ethics.

3.2 Research methods used by previous researchers in this field

In order to identify a suitable methodology for this study, the methodologies that have been have been adopted by previous researchers are listed and formally reviewed in Table 3.1.

Table 3.1 List of methodologies used by previous authors

Authors	Research question	Methods	Geographical scope	Pros	Cons
Monios, J., and Wang, Y. (2013)	Spatial and institutional characteristics of inland port development in China	Qualitative analysis	China	The theoretical framework is drawn from the literature which has strong reliability.	Extensive first hand data for the model are difficult to collect.
Roso (2015)	Seaport-inland port dyad dynamics: an investigation of service provisions and intermodal transportation linkages	Qualitative methods in term of face-to-face semi-structure interviews	US, Australia and Sweden	First hand data are gained.	Number of interviewees may be limited owing to site visits.
Notteboom (2005)	Port regionalization: towards a new phase in port development	Conceptual approach	Theoretical research	New phase derived from literature review.	Extensive reading needed on previous research.
Hanaoka (2011)	Promoting intermodal freight transport through the development of dry ports in Asia: An environmental perspective	Desktop research (literature review)	Summarisation of state of art researches	Reveal new research direction based on reviewed articles.	Of limited value, only good in the preliminary stages.
Monios (2015)	Identifying Governance Relationships Between Intermodal Terminals and Logistics Platforms	Conceptual (Governance theory deriving from inductive methodology)	Theoretical research	Typology is derived by inductive methodology of governance relationships.	Extensive reading needed in order to derive justifiable conclusions.

Monios, J. and Wilmsmeier, G., (2013)	The role of intermodal transport in port regionalisation	Conceptual (deriving from the literature)	Theoretical research	Identify difficulties arising from the nature of intermodal transport that challenge successful implementation of port regionalisation.	Extensive reading needed in order to derive justifiable conclusions.
Bärthel (2004)	Developing intermodal transport for small flows over short distances	Technological systems approach and also qualitative methods in data collection	Swedish	Providing a tool for empirical delineation of system assessed.	In-depth information of case studies is required.
Colicchia (2017)	Lean and green supply chain management through intermodal transport: insights from the fast moving consumer goods industry	Scenario-based/Modelling, also employing case study in one industry to investigate challenges.	Italy	Provides a quantification of potential demand for intermodal transport.	Highly based on cases chosen. Potential over-simplification of the issue.
Jacobsson (2017)	Access management in intermodal freight transportation: An explorative study of information attributes, actors, resources and activities	Case studies depend on semi-structured interview	Sweden	Case studies are reliable for theory-building and provide a better understanding of the data and explanations of "best practices". Allows focus on key issues.	Interview questions need to be designed carefully to collect useful data. Difficult to make generalisations.
Dotoli (2010)	The impact of ICT on intermodal transportation systems: A modelling approach by Petri nets	Employing Petri Nets (PN) For modelling and controlling intermodal transportation systems	Italy	Qualitative methodology could show the efficiency of the controlling approaches straighter forward.	Needs strong mathematic and programming background. Validity on other cases is under suspicion.

				For the ideal results, changes to the approaches could be located easier.	
Ballis (2004)	Towards the improvement of a combined transport chain performance	Micro-model (expert system) for comparative evaluation of different objects and a macro-model.	EU	It is useful for establishing the proper structure and ensuring optimum operation for a national network.	The models are considered as a rather unrealistic assumption.
Islam (2016)	How to make modal shift from road to rail possible in the European transport market, as aspired to in the EU Transport White Paper 2011	Desktop research (literature survey) and group discussion	EU	Good way to collect first hand data and usually the results have great practicability. Can provide deeper insights into main issues.	Group discussions difficult to organise and manage.
Ricci (2016)	Assessment Methods for Innovative Operational Measures and Technologies for Intermodal Freight Terminals	Analytical method is employed to measure the performances of terminal at present and after the implementation of scenarios	Germany	Model is not complexed and can be achieved by software.	Theoretical knowledge for each function used in subsystem are needed.
Woodburn (2017)	An analysis of rail freight operational efficiency and mode share in the British port-hinterland container market	Observation survey	British	Good way to collect first hand data.	Time consuming to generate relevant data.

Van den Berg (2012)	The role of port authorities in new intermodal service development; the case of Barcelona Port Authority	Case study	Barcelona	Good way to collect first hand data accompany with available second-hand data from annual reports, strategic plans, presentations and statistics.	Time consuming to generate relevant data.
Bergqvist (2012)	Green port dues — The case of hinterland transport	Desktop research - framework derived from research literature	Theoretical research	No mathematical data or methods needed. Accessibility of research outputs.	Extensive reading is needed.
Nguyen (2016)	A Multi-Criteria Approach to Dry Port Location in Developing Economies with Application to Vietnam	Methodological approaches with Likert scale	Vietnam	Fit the research to find out whether one alternative is preferred over another, not their exact value.	Bias exists in the weight for each criterion relies on subjective judgements.
Lammgård (2012)	Intermodal train services: A business challenge and a measure for decarbonisation for logistics service providers.	In-depth interviews	Sweden	Good way to collect first hand data for longitudinal studies. Can provide meaningful insights.	Time consuming to generate relevant data.
Saeedi (2017)	Analyzing competition in intermodal freight transport networks: The market implication of business consolidation strategies	Proportional fairness algorithm is adopted to assess market concentration	Conceptual research	Conceptual papers have a place in academic research.	Requires strong mathematical background. Modelling clouds the real issue.

Álvarez-SanJaime (2013)	Vertical integration and exclusivities in maritime freight transport	Model to test whether a vertically integrated company prefers to keep a dedicated or to let it to a rival liner	Theoretically	No data needed.	Model is under specific assumptions. Questionable the extent to which model reflects reality.
Wilmsmeier , G et al. (2011)	The directional development of intermodal freight corridors in relation to inland terminals	Conceptual modelling and theoretical research	Sweden, Scotland and USA	Provide research agenda for additional case studies.	Results gained has strong relevance on cases. An element of triangulation.
Chen (2017)	A Delphi analysis on green performance evaluation indices for ports in China	Using Delphi technique to identify a set of applicable and practical green performance evaluation indices.	China	The Delphi technique has been widely employed to identify and explore indicators and criteria for unknown and uncertain consensuses, and it has been widely used in the logistics field.	More subjects are needed for various reference groups.
Lirn (2013)	Green performance criteria for sustainable ports in Asia	AHP round survey	Asia	Fit the research topic and targets	Survey limitations, can only examine general issues, not specifics.

According to the review the methods adopted in related research in terms of intermodal transport and green port management, surveys and interviews are the most common format of data collection when the researcher either investigates new field of study or intends to ascertain and theorize prominent issues (Corbin J, 2008).

Interview is a prevailing primary method of data collection in qualitative research. There are basically three types of interview methodology: structured, semi-structured and unstructured, and all of them consist of a series of questions being asked during a two-way conversation (Gill, 2008). The structured interviews usually adopt verbally administered questionnaires in which the predetermined questions are asked. This is quick and easy to manage as little or no variation or follow-up questions that need further illustration. This is usually associated with positivistic research, where short clear answers are required in an attempt to identify an ‘average’ respondent, however that is defined. But it will also restrict the depth of data digging because the responses from participant are limited. In converse, unstructured interviews allow open ended responses from interviewee and do not reflect any preconceived theories. Nevertheless, although commonly termed unstructured, the term ‘loosely structure’ is probably more appropriate, as in order to be methodical some form of structure should be employed, even if the researcher preparations are not focused on questions to be asked but rather topics to be covered. The shortcomings of this method are obvious: it is very time-consuming and can be difficult to manage because of no predetermined guideline questions. It therefore should only be undertaken by an experienced researcher. Semi-structured interviews consist of several key questions that help to define the areas to be explored, but also allow the interviewer or interviewee to expand their dialogue in order to discover key problems. From the paper by Nielsen, J. and D’haen, S. (2014) which reviewed 82 articles to find out the methodology used in qualitative climate change research from 2000 to 2012, 92 percent were adopted interviews; and most often a form of semi-structured or in-depth interview. Interviewees were most commonly selected based on profession, residence and age. Semi-structured interviews were employed in analysing safety issue in work operations in Portugal ports by (Motter, 2017).

Another qualitative method that employed widely in data collection is questionnaire. The interviews are completed by send questionnaires from interviewer to selected interviewee (by mail, email or in-person) and collected back once they finish. The major difference

between a questionnaire and an interview is that while both of them can provide open-ended questions and a series of closed-ended questions, the interview presents the opportunity for an immediate follow up on the issue being examined. Usually doing the survey by questionnaire however has the advantages such as low cost, time saving and scalability. However, sometimes it is hard to collect the desired data because of fake answers, i.e. systematic biases, differences in understanding and difficulties in getting responses from the interviewee. In the research of Quintana (2016) semi-structured questionnaires were applied to 30 port managers to investigate innovations in Brazil port environment management for 3 years. Wan et al. (2018) also used questionnaire to collect data from port managers to evaluate the development of Chinese green port indexes. The collected data was then processed by using the hybrid approach of Analytic Hierarchy Process (AHP) and Evidential Reasoning.

3.3 Use of qualitative methodologies

By a research strategy, quantitative research can be construed as a research strategy that emphasizes quantification in the collection and analysis of data and that:

- Entails a deductive approach to the relationship between theory and research, in which the accent is placed on the testing of theories;
- Has incorporated the practices and norms of the natural scientific model and of positivism in particular; and embodies a view of social reality as an external, objective reality, which is singular in nature, hence can be ‘measured’.

By contrast, qualitative research can be construed as a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data and that:

- Predominantly emphasizes an inductive approach to the relationship between theory and research, in which the emphasis is placed on the generation of theories;
- Has rejected the practices and norms of that natural scientific model and of positivism in particular in preference for an emphasis on the ways in which individuals interpret their social world;
- Embodies a view of social reality as a constantly shifting emergent property of individuals’ creation, hence there exist multiple realities.

More specifically, the key differences between qualitative and quantitative research can be drawn clearly on the following grounds (Yilmaz, K., 2013):

1. Qualitative research is a method of inquire that develops understanding of human and social sciences, to find the way people think and feel. A scientific and empirical research method that is used to generate numerical data, by employing statistical, logical and mathematical technique is quantitative research.
2. Qualitative research is holistic in nature while quantitative research is particularistic.
3. The qualitative research follows a subjective approach as the researcher is intimately involved, whereas the approach of quantitative research is objective, as the researcher is uninvolved and attempts to precise the observations and analysis on the topic to answer the inquiry.

4. Qualitative research is exploratory. As opposed to quantitative research which is confirmatory/conclusive.
5. The reasoning used to synthesize data in qualitative research is inductive whereas in the case of quantitative research the reasoning is deductive.
6. Qualitative research is based on purposive sampling, where a small sample size is selected with a view to get a thorough understanding of the target concept. On the other hand, quantitative research relies on random sampling; wherein a large representative sample is chosen in order to extrapolate the results to the whole population.
7. Verbal data are collected in qualitative research. Conversely, in quantitative research measurable data is gathered.
8. Inquiry in qualitative research is process-oriented, which is not the case of quantitative research.
9. The hypothesis is generated in qualitative research by inductive reasoning. On the contrary, the hypothesis is tested by deductive research in quantitative reasoning.
10. Elements used in the analysis of qualitative research are words, pictures, and objects while that of quantitative research is numerical data.
11. Qualitative Research is conducted with the aim of exploring and discovering ideas used in the ongoing processes. As opposed to quantitative research the purpose is to examine cause and effect relationship between variables.
12. Lastly, the methods used in qualitative research are in-depth interviews, focus groups, etc. In contrast, the methods of conducting quantitative research are structured interviews and observations.
13. Qualitative Research develops the initial understanding whereas quantitative research recommends a final course of action.

Research methods can be and are associated with different kinds of research design. An ideal research is one which is conducted by considering both the methods where qualitative research tends to be interpretative, quantitative research is 'factual', or at least, where a common understanding of the 'facts' can be identified.

3.4 Case study design

According to Yin (2014) a case study is likely to be adopted when the research questions are more explanatory such as ‘how’ and ‘why’. Case study research is ‘a way of investigating an empirical topic by following a set of pre-specified procedures’ ‘case study is preferred when examining contemporary events and over which a researcher has little or no control’. Generally, single and multiple-case studies are the two variants of case study designs. Yin (2003) explains that when the researcher chooses to do a multiple case study, they are able to analyse the data within each situation and also across different situations, unlike when a single case study is chosen. In addition, the same author Yin (2009) stressed again that multiple-case studies are better than single case designs due to single-case designs “put all eggs in one basket” where analysing more cases can be beneficial from having two or more sources for substantial knowledge. However, from another side, according to Baxter & Jack (2008), there can be an expensive and time-consuming process to make a multiple case study. And some single case studies are better when the researcher wants to have a deeper understanding of the exploring subject Dyer and Wilkins (1991). As the choice of research method should clearly depend on the problem under study, in this research, the green port tool in Chinese ports is the current focus and the questions of ‘how’ and ‘why’ will be pursued through the interview in specific instances. This makes the case study research a best suitable method for gathering knowledge about, and analysing the gap between Chinese ports and developed countries. The primary research in this thesis will therefore be planned and executed as case study research with multiple cases.

The study of this thesis is based on two cases studies of Ningbo-Zhoushan Port and Dalian Port which are located in south east China and north east China respectively, and both have a long history among China’s ports and in 2016 were ranked in the world’s top 20 ports by throughput number (Lloydslist.com., 2016). Interviews were used to gain an overall understanding of the cases green port tools and their future strategy toward promoting green port performance. In terms of interview preparation, the interview was performed after the formal literature review, and hence this allowed a basic idea of the key issues to be developed in the course of the interviews. Hence it was judged that the semi-structured interview form would be the most appropriate to cover the needed information to help with the answering of the key issues to be addressed. In addition, the semi-structured interview will lead to ‘getting back on track’ when the interview gets into

a siding, by going back to the questions from the interview, and given the limited experience of the researcher in this instance, this was seen as a key advantage, particularly over the unstructured interview.

Before the interview, the data material about the case companies was reviewed and analysed in order to provide some form of time period context, hence issues over the medium and even longer terms could be discussed during the interview. A component therefore of the semi-structured interview was based on historical data, which gave the basis to achieve insights to events that occurred before the start of the case study. The primary data collected from the interviews was also used to better structure the case study and to link findings from the literature review to the case study subjects. Beside primary data, secondary data was based on already existing data such as journal papers, company annual reports, national annual reports and policy documents. The information collected from the internet that are relevant to the research need to be carefully selected. For example, the data from case company's homepage is assessed as high quality secondary empirical data. Finally, the supervisors' corrections, comments and suggestions have also been carefully considered throughout the process of writing the thesis.

How to analyse case data is another important process of a successful qualitative research. It is not merely a descriptive but a critical exercise, typically an examination of a situation with view towards decision making (Unb.ca., 2018). The analyses need to determine the critical elements relevant to the research projects' main aim, identify who are the relevant stakeholders to the situation and those affected by the decisions to be made, and finally to identify the constraints and opportunities implicit to the situation. In this research, the analysis will connect observations of contemporary China's green port management situation with the experiences summarized from developed countries, and identify the main challenges that may impede Chinese ports achieving their sustainable development as part of the wider 'green' agenda.

3.5 Case selection

Two ports which are in the top 20 ports in the world and pioneers in Chinese green port development are selected as cases. Ningbo-Zhoushan port and Dalian port are two representative ports in south and north China. The two ports are both located at opposite

geographic areas of the country which allows comparative analysis. Although the throughput of Dalian port has stagnated in recent years, and thus the ranking has fallen in world terms, it still ranked the 11 largest port by throughput in world in 2015. The two ports play a key role in their economic belt and have large developing potential under the Chinese ‘13th Five-year Plan’ and ‘21st Century Maritime Silk Road’ initiative background. Besides, both ports pay attention to green port construction and set specific funds and project for it. Ningbo Beilun No. 2 container dock and Dalian ore terminal were chosen respectively by Ningbo-Zhoushan port and Dalian port as pilot terminals for green port construction. There are rail tracks that connect the port with the national railway network in the two ports (although in Ningbo-Zhoushan port the rail infrastructure is still under construction). ‘Station at port’ provide a seamless connection between sea and rail modal transfer in Dalian and pave the way for cargo shipped to hinterland cities from port. Tracks in Dalian port district are owned by Dalian Port Company Limited (PDA) and operated by Dalian Port Railway Corporation. Cargo consolidation and logistics services are run by Dalian Jinyi Logistics Co., Ltd. which is also invested by the PDA. In 2016, Dalian port transferred 406 thousand TEUs (4.3% of annual throughput) by sea-rail transport and Ningbo-Zhoushan port did 250 thousand¹ (1.02% of annual throughput) (ChinaPortYearBook, 2016). Although the sea-rail intermodal business is weak comparing to that in Port of Rotterdam (around 12% in 2012) and Port of Antwerp (7% in 2015), they are ports perform quit well in China for now. Key data on each port are presented in Table 3.2.

¹ Currently moved by truck to the nearest rail head until the rail line is completed.

Table 3.2 Key data on the two case ports in 2016

Category	Port of Ningbo-Zhoushan	Port of Dalian
Geographical location on Chinese coast	Middle	North
Throughput (million tons)	9,200	3,500
Container throughput (TEU)	21,560,000	9,440,000
Productive berths over ten thousand tons	163	103
Terminals with on-shore power supply	2	2
Transport modal share of inland container movements (road; rail; water)	86% : 1% : 13%	54% : 4% : 42%
Main containerized cargo type	Light cargo (textile, plastic and electronic components)	Heavy cargo (commodity auto and spare parts, wood ware and glass)

It can be seen from table 3.2 that both ports have 2 terminals which have employed on-shore power supply system. Therefore, the selected ports have started their greening process and on-shore power supply service may enjoy the same importance in their green port management strategy. This should be the first requirement in case selection because the port should have started to implement some green port tools so that they can be cases to show green port management in China.

The economic condition of port largely relies on convenience of its transportation, frequent trade activities will attract more conveyance heading to port. According to the green port tool in inland transport system reviewed in section 2.4.3, the modal share of cargo transportation is an important index to show the degree of port development and more specifically, the greening of the port. Both ports have railway terminal that could connect the port with national railway network, however, table 3.2 shows that road transportation constitutes largest part of transport modal share of inland container

movements in the two ports. Therefore, the selection of two cases with one in north and one in the middle could generally tell the bottleneck in inland transportation in China.

In addition, main containerized cargo type in Dalian port is heavy cargo. Comparing to light goods, for same transportation distance same truck should generate more emissions and pollutants per container. Therefore, the measure taken by Dalian port to mitigate emissions and pollutants in port area as well as in hinterland transportation should be an interesting question

From the view of economic, policy and geographic, the selected cases are qualified. With the implementation of ‘One Belt and One Road (OBOR)’ initiative, these two ports will participate more prosperous trade activities as they have been proposed in Chinese ‘going global strategy’ along the OBOR (Chen et al. (2018)). They have started to search the way to become green port and will have potential to succeed with the policy support from the state government.

Dalian port and Ningbo-Zhoushan Port are playing key roles in their economic belts. Dalian port is the biggest port in northeast China and its development boosts the development of inland economy, and vice versa. The economy hinterland of Dalian port geographically covering the lands of whole three provinces in northeast of China and even several cities of Inner Mongolia. These hinterlands are important bases of heavy industry and grain productions for a long time. Therefore, numbers of food factories, chemical plants and other manufacture plants rely their import and export trade activities on Dalian port. Hence the port has its unique position in north China’s port system.

Ningbo-Zhoushan port ranked first with its largest container throughput number in Chinese ports in 2016. In addition, Ningbo city is the second economic centre in Zhejiang Province. Located at the coastal of the East China Sea, Ningbo-Zhoushan port is the combination of old Ningbo and Zhoushan ports geographically. After integration with other feeder ports in Zhejiang province, Ningbo-Zhoushan port now could attract cargos from China’s largest marine products production base (in Zhoushan) and more processing base, textile and plastic factories from more hinterland cities. Hence, Ningbo-Zhoushan port is also an importance port in central south China.

In conclusion, both ports did pay attention to green port construction and already have mature operation mechanism and good business condition. Based on the policy and developing strategy mentioned before, they are two of the ports that have large potential to be develop into green ports in the near future.

3.6 Data collection

The data for the two case studies is primarily qualitative and drawn from documentary sources and semi-structured interviews.

The documentary sources include ‘Development strategy of Ningbo-Zhoushan port’ the report developed by Ningbo-Zhoushan Port Group Co., Ltd. ‘Ningbo Transportation Economic Statistics Special Survey Report’ ‘Ningbo Traffic Year Book 2016’ published by Ningbo Transportation Committee. ‘Hinterland container business development planning in the 13th Five Year Plan’ by Ningbo-Zhoushan port authority.

‘Port intermodal transport research report’ from China port association-port intermodal transport branch (based in Dalian). ‘Construction of intermodal transport in Dalian port’ from Dalian port company. ‘China port association green port evaluation guideline’ from China port association. ‘China Ports Year Book 2016’ published by ‘China Ports magazine’. All the documents except the last one is restricted material that cannot be accessed by the general public online or in the library. The ‘China Ports Year Book’ is published yearly with all Chinese ports’ current statues, achievement and changes in the year it shows. All the material collected in paper version were in Chinese.

More data were collected from national government website (www.gov.cn) and local government website (www.Nbplan.gov.cn), Ningbo-Zhoushan Port Company (www.Portnbzs.com.cn) and Dalian Port Company (www.dlport.cn)’s websites.

The interview questions are designed on the basis of green port tools summarised in paper of Lam and Notteboom (2014) and rearranged into three main parts. Policy tools such as pricing policy, monitoring and measuring, market access control and environmental standard regulation are merged as sub-questions under the title of control the emission from ships, port activities and in-land transportation. This allows these individual elements of port activities to be more closely examined. All the listed questions are trying

to identify the strategy that is already employed in the port, and the challenges and the weak points that need to be addressed in next step.

There are 7 interviewees in total had been interviewed face by face in their offices, therefore the author have made 7 visits with 5 in Ningbo City and 2 in Dalian City to operate the interview. All of them have more than 10 year working experiences at the interview time, August to September, 2017. 5 interviewees were from Ningbo-Zhoushan Port, one manager of Ningbo-Zhoushan Port Company Chuanshan Port Area container terminal, one project manager of green and safety department manager in Ningbo-Zhoushan Port Company Chuanshan Port Area container terminal, one manager of Ningbo-Zhoushan Port Company intermodal transport department, one staff from Ningbo-Zhoushan Port Company intermodal transport department and one manager of Ningbo-Zhoushan Port Company logistics department. Owing to limited time schedule, for Dalian Port, the Dalian Port Company container limited manager had been visited in Dalian Port Area who is also the vice chair of China intermodal transport association (north east part). Most internal statistics and material on Dalian Port were collected from him. Finally, one officer working for China Maritime Safety Administration Dalian Branch were interviewed. Although the materials collected in Dalian port were less than that in Ningbo, concise overview of Dalian Port could be drawn.

This mix of views provide a degree of triangulation in the research. The two container terminal head managers who work in port area are directly engaged in port operations and know more information inside of the port. Also, to some extent they can express the opinion of shipper and ship owner on port pricing tools or other green port tools. Then the other three interviewees in Ningbo-Zhoushan port company tend to be more on the policy and business side of the port. The Dalian Port Company container limited manager is not only eligible for pre-mentioned quality but also provide more information from strategy perspective as he is also the vice chair of China intermodal transport association (northeast part). As for the officer in China Maritime Safety Administration Dalian Branch, he provides the views from the governance stand point, which more relate to ship emission control criteria.

Before the interview, guideline questions were sent to interviewees in advance and gifts were given in return after the interview. Whilst in some contexts this may be viewed as

introducing extreme bias into the process (e.g. affirmation bias), in China the tradition is to give a small gift in return for (in this case) the participants' time and attention to the study. A brief profile of the chosen interviewees is listed below.

Table 3.3 Information about interviewees

Affiliation	Working experiences in this field
Ningbo-Zhoushan Port Company intermodal transport department manager	Over 10 years
Ningbo-Zhoushan Port Company intermodal transport staff	Over 10 years
Ningbo-Zhoushan Port Company container terminal green and safety department manager	Over 15 years
Ningbo-Zhoushan Port Company container terminal manager	Over 20 years
Ningbo-Zhoushan Port Company logistics department manager	Over 20 years
Dalian Port Company container limited manager (Vice chair of China intermodal transport association (north east part))	Over 20 years
Officer in China Maritime Safety Administration Dalian Branch	Over 20 years

In the first instances, all the interviewees have a strong understanding of green port tools that are employed by Chinese ports and those who can participate in or influence its decision-making process. All of the informants have more than ten years working experience in port management fields therefore their answers should have strong reference value. Instead of pasting the full transcripts in the research report, the interview records and materials collected from the interviewees were fully written up into research notes to the responses to each key questions. The research notes provide aggregated responses for each of the 7 overarching interview questions for each case study port. Detailed contents can be found in Appendix.

In order to have a successful interview, besides appropriate interview questions, there are valuable quality summarized by Harvey, W. (2011) that the interviewer should be:

1. Knowledgeable: is thoroughly familiar with the focus of the interview; pilot interviews of the kind used in survey interviewing can be useful here.
2. Structuring: gives purpose for interview; rounds it off; asks whether interviewee has questions.
3. Clear: asks simple, easy, short questions; no jargon.
4. Gentle: let people finish; give them time to think; tolerate pauses.
5. Sensitive: listens attentively to what is said and how it is said; is empathetic in dealing

with the interviewee.

6. Open: responds to what is important to interviewee and is flexible.
7. Steering: knows what he/she wants to find out.
8. Critical: is prepared to challenge what is said, for example, dealing with inconsistencies in interviewees' replies.
9. Remembering: relates what is said to what has previously been said.
10. Interpreting: clarifies and extends meanings of interviewees' statements, but without imposing meaning on them.
11. Balanced: does not talk too much, which may make the interviewee passive, and does not talk too little, which may result in the interviewee feeling he or she is not talking along the right lines.
12. Ethically sensitive: is sensitive to the ethical dimension of interviewing, ensuring the interviewee appreciates what the research is about, its purposes, and that his or her answers will be treated confidentially

3.7 Data analysis

The green port goals were divided into three main types: controlling the emissions from ships, port activity and inland transportation, following Axel, B. N. (Ed.). (2011). A list of green port strategies summarised from the literature reviewed was used in the interviews to find the strategies that are already employed in the ports, and then interviewees were asked about the challenges and the weak points that need to be addressed in future. The interviews were recorded, transcribed and then written up as research notes in order to identify key points and issues.

After generating the first sketch, the annotation of abbreviation were added and changes of colloquial words made according to the secondhand data and documents. Then the separated notes for each interviewee were aggregated to develop research notes for the 7 overarching interview questions for each case study port. The repeated information was filtered out to make sure the research notes are exhaustively and completely. After that, the logic of the full draft was checked and where necessary, changes made. All the material was originally written in Chinese because the interviewees were all local Chinese people. Then the second draft was sent to supervisor to evaluate the quality of information, and discuss the amendments that were required. Furthermore, there may exists some places that would cause ambiguity or the misunderstanding by the author. Therefore these

were double checked with brief follow up questions by message to the respondents after the interview.

To translate the results in English was also an important procedure. Large number of related articles were reviewed to ensure that all text and prose was consistent with the terminology that is generally used in the professional field and accepted by the public. At this stage, as the research should be evidence based and hence strictly source-oriented, it was checked that no purely personal opinions were be added in the transcription process.

In order to draw out the key issues underlying green port development in China, a SWOT analysis (Bunting, 2015) was undertaken. This allowed the possibility to extract a concise depiction of the strategic landscape of China's green port management from fragmentary interview results. This allowed a set of key criteria to be developed (in conjunction with the literature review) against which a port's 'greenness' could be assessed. In other words, the extent of key actions taken to mitigate against environmentally damaging externalities arising out of port operations.

The SWOT is a strategic planning technique employed to help a person or organization identify strengths, weaknesses, opportunities, and threats related to business competition or project planning. The strengths and weaknesses are internal to the organization which are called internal factors, and the opportunities and threats presented by the environment external to the organization are named as external factors. When it comes to this research topic, the strengths should be characteristics of the port environmental friendly management tools that give it an advantage over others. Weaknesses refer to characteristics of the green port tools that port adopted that place itself at a disadvantage relative to others. Opportunities are elements in the environment that the port could exploit to its advantage which can form the viewpoints of policy, economic and technical. Finally, the threats could be elements in the environment that could cause trouble for the port to become a green port (shown in table 3.4). SWOT analysis can help the port to assess its competitive strength and the nature of its external environment thus enable to draw out the key factors that underpin the development of green ports in China in the end.

Table 3.4 Diagram of SWOT matrix used in this research

Internal factors	Strengths		Weaknesses	
	Ship emission		Ship emission	
	Port activities		Port activities	
	Port hinterland transportation		Port hinterland transportation	
External factors	Opportunities		Threats	
	Ship emission		Ship emission	
	Port activities		Port activities	
	Port hinterland transportation		Port hinterland transportation	

SWOT is a large part of the strategic planning process owing to its advantages. Firstly, it is a multi-level analysis which could gain valuable information about the objective's chances by viewing each of the four elements of the SWOT analysis independently or in combination. Secondly, the data integration. SWOT analysis requires the combination of quantitative and qualitative information from a number of sources. Access to a range of data from multiple sources improves enterprise-level planning and policy-making, enhances decision-making, improves communication and helps to coordinate operations. In addition, the SWOT analysis has the properties of simplicity, low costs and time saving. Based on an intuitive analysis, the SWOT can also lead to more convincing conclusions without accurate data support and more specialized analysis tools.

However, lacking of specialized analyzation makes SWOT flawed with insufficient precision inevitably. For example, SWOT analysis uses a qualitative method by listing various strengths, weaknesses, opportunities and threats performances may form an ambiguous description of the competitive position of the enterprise. Therefore the results derived only from SWOT may subject to a certain degree of a subjective view inevitably. Besides, as the SWOT analysis is a snapshot of the firm at a particular moment in time, the analysis might obscure the fact that both the internal and external environment are rapidly changing. It is only a starting point for discussion and cannot, in itself, show managers how to achieve a competitive advantage. All of these disadvantages suggest that it should be better to employ SWOT analysis together with other analyzation tools to develop more fairly results.

In this research, the SWOT analysis is employed in the first step in data analyzation to clarify the information collected from interviewees who joined the semi-structured interview in order to draw a better understanding of the factual overall situations in two case ports. After that, the green port tools that employed in the case ports (basically the items listed in strengths and weakness) are then compared with the ones in world-wide green ports' in one matrix to indicate the gap as well as differences. Following that track, an in-depth analyzation is provided in the end to draw out the key factors that underpin the development of green ports in China.

3.8 Validity and reliability

Validity and reliability are key aspects of all research. High levels of both are normally associated with quantitative based research, but also both need to be carefully considered in qualitatively based research. Validity in research is concerned with the accuracy and truthfulness of scientific findings (Brink, 1993). A valid study should demonstrate what actually exists and a valid instrument or measure should actually measure what it is supposed to measure. Reliability is concerned with the consistency, stability and repeatability of the informant's accounts as well as the investigators' ability to collect and record information accurately. It refers to the ability of a research method to yield consistently the same results over repeated testing periods. Because of the researcher's subjectivity may interrupt the research findings, validity and reliability are often questioned or viewed with skepticism by the scientific community. Therefore, the researchers need to be attuned to the multiple factors that pose risks to the validity of their findings; and plan and implement various tactics or strategies into each stage of the research project to avoid or weaken these threatening factors.

The main risks to validity and reliability of qualitative research are lying in:

- The researcher
- The subjects participating in the project
- The situation or social context
- The methods of data collection and analysis

Firstly, in a qualitative study the data-gathering instrument is frequently the researcher them self. Thus, questions of researcher bias and researcher competency, if unchecked, may influence the trustworthiness of data. This may also be introduced by the tendency of the researcher to observe subjects and interpret findings in the light of their own values, the tendency to selectively observe and record certain data at the expense of other data. So, the researcher needs to be aware of the possibility of introducing bias at various points of the research process. The researcher therefore should always assess and gauge the relationships with the subjects being studied in order to enter or get close to the people or situation under study, or to move from a stranger or distrusted person to a trusted and friendly person during the research process. These processes however need to be managed very carefully in order to minimize researcher biases.

Secondly, the truth of responses is a key concern when data are obtained through questionnaires and interviews. In order to increase the validity of responses, the following seven tips will be followed in this study (Anderson, C., 2010):

- By making sure that interviewees are very clear on the nature of the research e.g. why the researcher is there, what they are studying, how they collect data and what they will do with it
- By first building a trust-relationship with the subjects and staying in that setting for a long period of time
- By comparing the results obtained with other evidence
- By keeping accurate and detailed field notes to note the variations in responses over the course of time
- By showing field notes to a second outside researcher. Another researcher is often much quicker to see where or how a fieldworker is being misled or coopted.

Thirdly, the social context under which the data are gathered is an important consideration in establishing validity and reliability of data. In my research the interview places are planned at the offices of interviewees, and most of informants should have individual office. Hence the social context influences could be avoided.

And the last but not least, because reliability and validity depend on the potential for subsequent researchers to reconstruct original strategies, the researcher who presents a

vague account of their design is putting themselves at risk of being accused of invalid and unreliable findings. Therefore, in this dissertation the methods are presented clearly, which is precisely identify and thoroughly describe all strategies used to collect the data and carefully document the field notes in the context of what was being observed. This should enable fellow researchers to form a valid judgment on the issues of the level of reliability and validity in the current study.

3.9 Research ethics

During the qualitative research process, according to Bryman (2015) ethical principles influence the legitimacy of the study. This is because during the procedure, the researcher is involved in all stages of the study from defining a concept through the various stages in design, interview, transcription, analysis, verification and reporting the concepts and themes. Thus, ethical concerns need to be taken into account because a human being is an integral part of this process. Ryen (2011) suggest that the power in the interview process may not be equal, calling for the ethical principles to create a comfortable atmosphere and to ensure the quality of the qualitative research. Theoretically speaking, the research should not produce unreasonable demands on the participants; taking a universalist ethical stance (Bryman, 2015), there should be consent forms offered to the intended respondents; the participants should feel free to take part in the research without any coercion; the participants should be informed of any risk or adverse consequence triggered by the research; participants' confidentiality and anonymity should be protected and respected. Good ethical principles should not only be able to predict what might be arising, but also the unexpected situations (Ritchie, 2003). Here three ethical principles that are common across the board are: informed consent, anonymity, and confidentiality.

Under a universalist stance, researchers are expected to obtain informed consent from all those who are directly involved in research or in the vicinity of research. This principle adheres to a larger issue of respect to the participants so that they are not forced into participation and have access to relevant information prior to the consent. Usually consent is obtained through written consent forms which typically include prior information on key elements of research such as purpose, procedures, time period, risks, benefits, and a clause stipulating that participation is voluntary and the participants have the right to

withdraw from the study. During my study, the consents from interviewees were obtained by email, phone calls and key questions of the interview were sent in advance to make sure participants were happy to accommodate a visit by the researcher and felt able to give responses to the questions posed. Another concern in the interview is the researcher must endeavor to minimize the possibility of intrusion into the autonomy of study participants by all means (Sanjari, 2014). The principle of 'no harm' to participants ought to be considered by researchers, who should be aware of the potential harms that might be inflicted upon study subjects. Prior to the interviews, one issue identified was a potential conflict between the right to know and the right of privacy (confidentiality of port information) may happen. At one level, in the context of the current research on green port development status, this did not seem to be a sensitive area. However, at another level, when it came to the Chinese context, this required informants to talk about some policy issues which would concern areas of flaws in, and shortcomings of, governance. In these instances, interviewees were made aware of their rights to reject the question that they may be reluctant to answer. In addition, respondents were made aware of which persons would have access to the initial data and how the data might be used, and also that, the research would ensure that they will be anonymous in published work.

In the end, after the interview, the protection of the respondents' privacy and anonymity is paramount in terms of confidentiality. This is concerned with offering respect and protection to research participants through assurance of secrecy of information shared and anonymity by not revealing the identity of the individuals and institutions involved. Typically, anonymity is provided through the use of pseudonyms. Nevertheless, it is getting increasingly common for research ethics committees to seek documented proof of consent in a written, signed, and ideally, witnessed form. In this case, the researcher endeavored to do their best to protect their respondent's identity and hold the information strictly confidential as there would be no guarantee for it otherwise, and held the data securely with only the researcher and their director of studies had access to it.

4. Overview of green port policy and strategy in China

4.1 Introduction

This chapter will focus on the overview of green port policy and strategy in China. Firstly, an overview of Chinese port system is presented in 4.1, then the state of art china's green port policy in and strategies in 4.2 were reviewed afterwards.

4.2 Overview of the Chinese port system

Since China started economic reform and its Open-door policy in 1978, China has gradually become more integrated with the global economy. In the meanwhile, Chinese port has owned a simultaneous expansion of both capacity and throughput to support the export-driven economy. After 40 years, China is home to the largest port system and its scale of port development is unique from the traditional landlord port system found in most key ports around the world. According to Guan (2011), there are four distinctive periods in China's port development since the founding of the 'New China'. While Zhen (2013) states there were five distinguishable waves of intensive construction of Chinese ports. Here I will summarize their view and illustrate below.

I have divided the history Chinese port system in three main parts. The first stage was a centralization period dated from 1950s to 1970s (stage 1 in Fig.4.1). China was at the early stage of founding and the government still considered a potential military threat therefore the development of port system was slow and the port ownership and governance was highly centralized under the MOC, central government.

From late 1970s to 1990s (stage 2-4 in Fig.4.1) was a period of economic reform and the changing of the central planned economy toward a market-oriented one. With the implementation of open door policy, the key for the export-oriented economic strategy was the establishment of special economic zones in coastal cities where foreign and domestic enterprises were given favourable conditions for export in terms of taxation and preferential treatment. The shortage of port capacity, long ship waiting time and inadequate deep water berths could not support the needs of international business. In this

period, port construction played a crucial role in China's port history. During the construction, the national government developed a strong focus on Shanghai, Shenzhen and other main pivotal ports made them as the backbone of the port system; the major regional ports complement the main ports; and the medium-size and smaller ports are developed as appropriate. This had laid the foundation of the new port layout in 2006.

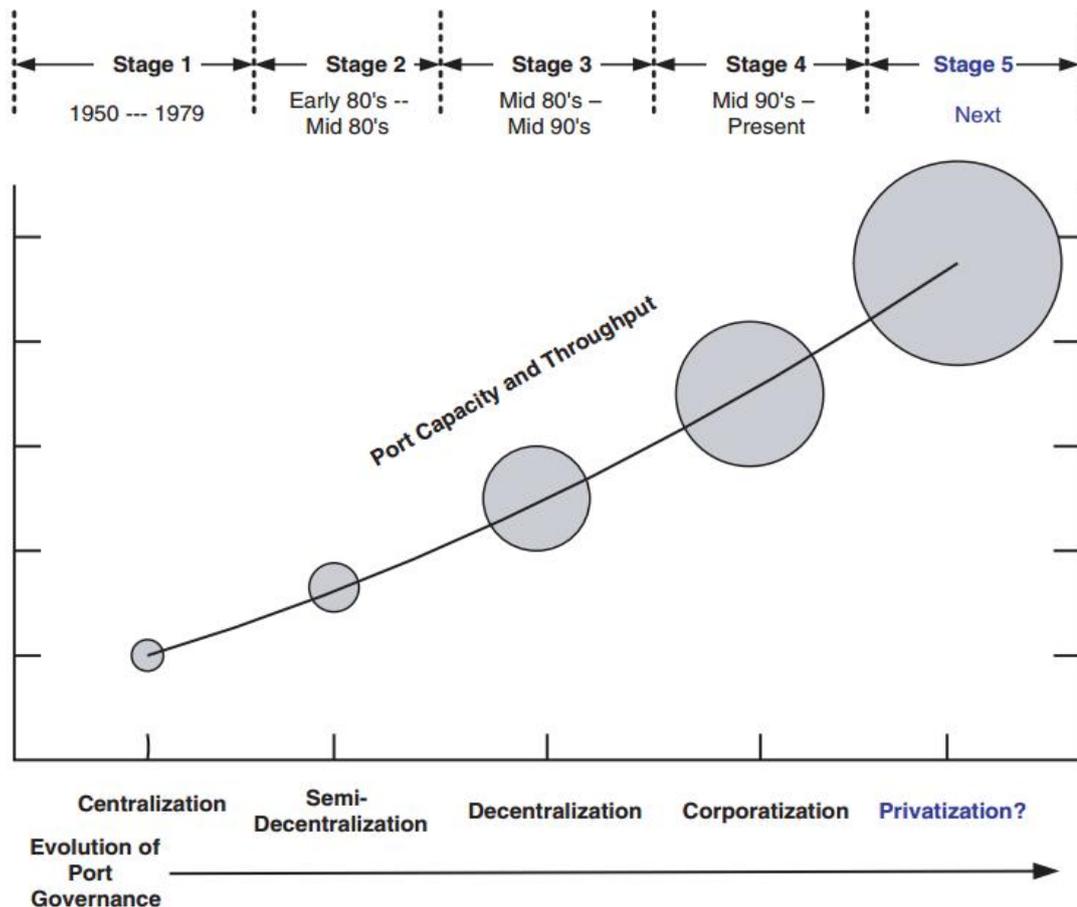


Figure 4.1 Summary of China's port reform (Guan, 2011).

Since the early 21st century to the present (stage 5 in Fig.4.1), China port system has experienced the third period. The implementation of Port Law in 2004 indicated the ultimate embodiment of the gradual shift from highly centralised ownership and decision-making to port governance landscape that offers more room for corporatization and private sector participation. The decentralization policy triggered a new round of port reform. The ports became more modernized and viewed explosive growth of throughput and capacity. Between 2001 and 2008, total annual throughput grew from 2.8 to 7.0 billion tons, and container throughput increased from 37 to 120 million 20-ft equivalent unit (Guan, 2011). At the end of 2010, Chinese coastal ports had a total of 5453 operational berths, and 1554 of these berths can serve ships of over 10,000 dwt. Until the

end of 2015, China had 31259 berths, including a total of 2221 berths having the capability of serving ships of over 10,000 dwt. Of these berths, 1807 are distributed among the country's coastal ports that capable of serving ships of 10,000 dwt (Stats.gov.cn., 2016).



Figure 4.2 Geography of the Chinese seaport system ((Notteboom, T. and Yang, Z., 2017).

Figure 4.2 provides an overview of the main seaports in today's China. According to the 'National Coastal Ports Layout and Plan' released by MOC in 2006, indicated that the construction and development of Chinese coastal ports will be formed into five large-scale, intensive and modern groups based on their characters of economic development, transportation relationships and main cargo type. Harbor group of circum-bohai sea area consists of the Liaoning, Jinji and Shandong coastal ports group. It mainly serves northern

coastal and inland regions of China of their socio-economic development. Liaoning coastal port group centres on Dalian northeast Asia international shipping centre and Yingkou port. And Jinji coastal port group centres on Tianjin northern international shipping centre and Qinhuangdao Port. Shandong coastal port group centres on Qingdao, Yantan and Rizhao ports.

Port group in Yangtze River Delta mainly depends on Shanghai international shipping centre, centres on Shanghai, Ningbo-Zhoushan and Lianyungang ports to serve the regions in the Delta as well as along the Yangtze River.

Port group in southeast coastal areas centres on Xiamen port and Fuzhou port to serve the socio-economic development of Fujian Province and Jiangxi Province as well as other inland provinces. In addition, this port group also undertake function to serve Taiwan Island under the direction of Chinese national government.

Port group in Pearl River Delta area mainly depend on Hong Kong international shipping centre, centres on Guangzhou, Shenzhen, Zhuhai and Shantou ports serve the regions in southern and southwest of China. And enhance the communication between inland cities and Guangdong Province.

Port group in southwest coastal area centres on Zhanjiang, Fangcheng Port and Haikou Port mainly serve the development of West China and expand of Hainan Province as well as its interflow of commodities out of the island.

The development of port industry and national provincial and even national economy are interdependent. With the continuous enlargement of the operating scale of Chinese ports, there formed three major economic supporting regions, Pearl River Delta area, Yangtze River Delta and Bohai Bay. The Pearl River Delta (PRD), more specifically the PRD Special Economic Zone was formally proposed in 1994 is one of the most economically vibrant zones in China because it used to rely on the advantages of national policies since the 1980s. It consists of 9 cities, namely Guangzhou, Shenzhen, Foshan, Zhuhai, Jiangmen, Zhongshan, Dongguan, Huizhou and Zhaoqing. In 2011, the PRD accounted for 9.2% of China's GDP with an average growth of 9.9%, and contributed 26.7% of China's total exports (Li, 2016). Major ports in PRD include Guangzhou Port, Yantian

Port, Shekou Port and Chiwan Port of Shenzhen, etc. In 2017, ports of Shenzhen were the world's third busiest container seaport after Shanghai and Singapore (China-trade-research.hktdc.com., 2018).

Yangtze Delta ports cluster mainly support the development of Yangtze River economic zone. Two decades ago, the port of Shanghai was the only one in the Yangtze River Delta region to be ranked among the world's top 100. While today it the Yangtze River Delta is the home to five of the world's top 100 container ports and has covered all the ports of Jiangsu, Zhejiang, Shanghai and Anhui. The 15 major ports in the region form the largest port cluster in East China in terms of capacity and handled a total of 4.17 billion tons of cargo and 78.08 million TEU (20-foot equivalent unit) containers in 2016, accounting for 35.2 percent and 35.8 percent of the nation's total respectively (Usa.chinadaily.com.cn., 2017).

Bohai economic circle consists of two municipalities directly under the Central Government including Beijing and Tianjin, four provinces including Liaoning, Hebei, Shanxi and Shandong, and the central part of Inner Mongolia Autonomous Region. The Circle covers a land area of 1.12 million sq. km., with a population of 260 million. Within this economic circle, there are 157 cities, making up one quarter of the country's total. Among them, 13 cities have a population reaching up to one million or more. Bohai economic circle's GDP accounts for more than one fourth of the country's total (English.gov.cn., 2015).

Table 4.1 provides the cargo throughput evolution since 2008 for the 10 Chinese seaports which were ranked in the China's top 10 ports in 2016. It can be seen that all the ports were belong to the three great economic zone. The year-on-year growth figures point to a weak 2009 and a more stable growth between 2012 and 2014. The listed seaports together realized a growth of 74.2% between 2008 and 2016, with Dalian, Ningbo-Zhoushan and Qingdao recording the highest figures (excluding the ports that rank after 50 in the world by container volume in 2016). In 2015, the overall throughput of the listed ports shows a speed down did not grow a lot compared to 2014, mainly caused by diversified hub port Shanghai. This observation provides indications that the fast development phase which started in the early 1980s has evolved to a period of less steep

throughput growth with even some tendency towards weak growth (Notteboom, T. and Yang, Z., 2017).

Table 4.1 Evolution of total cargo throughput in main Chinese ports (in million tons)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	Growth (2016/ 2008)	Growth (2016/ 2015)	Rank in world by container volume in 2016 (million TEU)
Ningbo-Zhoushan	520	576	633	694	744	809	873	889	922	77%	3.7%	4 (21.60)
Shanghai	508	494	563	624	637	682	669	649	645	27%	-0.62%	1 (37.13)
Tianjin	356	381	413	453	477	500	540	540	550	54%	1.85%	10 (14.49)
Guangzhou	347	364	411	431	435	455	482	500	522	50%	4.4%	7 (18.85)
Qingdao	300	315	350	372	406	450	468	484	500	67%	3.3%	8 (18.01)
Dalian	245	272	314	337	374	407	423	414	436	78%	5.3%	15 (9.61)
Yingkou	150	176	225	260	301	320	330	338	352	135%	4.1%	24 (6.08)
Rizhao	151	181	226	252	280	309	335	337	350	132%	3.8%	After 50
Yantai	111	123	150	180	203	221	237	251	265	139%	5.6%	After 50
Zhanjiang	67	118	136	155	171	180	202	220	256	282%	16.36%	After 50
Total	2755	3000	3421	3758	4028	4333	4559	4622	4798	74.2%	3.81%	
Y-O-Y growth rate (%)		8.89	14	9.85	7.18	7.57	5.22	1.38	3.81			

Source: authors' compilation based on data from National Bureau of Statistics China (2008-2016) (Stats.gov.cn., 2018).

Note: ranking based on figures in 2016.

4.3 China's green port policy and strategy

As the second largest economy in the world, China owns 7 of the world's top 10 container ports and handles 30% of the world's containers every year (Lloyds List, 2016). However, it is the world's largest emitter which contributed 23% GHG emissions in 2015 (Center For Global Development, 2016). China's port governance has been reformed extensively over the last decade, from centrally owned and managed ports to mixed ownership between central and local governments, to in most cases entirely local. Moreover, several ports have been merged into regional port authorities, in an effort to reduce wasteful competition between neighbouring ports and focus transport investment on intermodal corridors in the hinterland, supported by additional central government policies which still influence port management, for instance the National Development [2014] No. 32 which includes provisions related to green ports, safety and security (Notteboom and Yang, 2017). This section will consider the current status of green port tools in China, divided into ship emission controls, port activities themselves, and the port-inland transport system.

China as a member state is working hard to be in line with recent IMO environmental regulations. The state council of PRC put high priority on 'green transportation' and 'low-carbon economic development' in China's 12th Five-Year Plan (2011-2015) and 13th Five-Year Plan (2016-2020). New executive planning was released by China's Ministry of Communications (MOC) in 2015 including a plan for three Emission Control Areas (ECAs) requiring ships calling at the Pearl River Delta (PRD), the Yangtze River Delta (YRD) and the Bohai Bay to switch to lower sulphur fuel (no more than 0.5%*m/m*). This clause would apply on all national ships entering the three port regions and suggest international ships to change to lower sulphur fuel according to IMO regulation in ECAs. The Ministry of Communication set the goal that 10,000 vessels in the inland water fleet should be running on LNG by 2020.

The state council also pays attention to reduce emissions from port production activities. In 2016, the state council made an amendment to the existing Law about Prevention and Treatment of Air Pollution; the new added No. 63 clause states that “vessels staying at berth should use on-shore power as the first choice.” Moreover, the ‘Special action plan for the prevention and control of pollution from ports and ships’ mentioned that 50% of container ship berths in main port terminals should have the ability to provide shore side electricity for ships. China Ports & Harbours Association is the national society applying the maritime policies of the Chinese government. In 2015, this organization published ‘Guideline for Green Port Rating System (Trial Implementation)’ as a self-evaluating guide book for ports and a guideline for third parties to rank the green performance of ports. Tools like using intelligent control technology for outdoor lighting, changing the power of RTGs to electric, using LNG or electric powered vehicles in port, taking measure to protect terminals’ water ecosystem and the harbour district, operating risk assessments on the local ecosystem in port expansion projects and developing environmental pollution emergency plans for security production are all listed tools for ports to guide their green management (Chen and Pak, 2017). However, in fact, before the guide book came out, some individual ports had been making their own progress on green port management and evaluation. Shanghai Port Administration Centre used to publish a report on the environmental protection of Shanghai Port which indicated the Shanghai Municipal Port Administration Bureau was responsible for the supervision and management functions of the greening process of the port. The report in 2011 stated its environmental protection strategies dealing with air quality, waste water quality, noise level, solid waste volume and other ecological issue (Lirn, 2013).

Mitigating emissions from inland transport is at the early stages in China. Although China’s 13th five year plan and “the Belt and the Road Initiative” stress the development of intermodal transport in port distribution, there remains a lack of attention to this topic from the environmental perspective.

Consequently, it can be seen that the Chinese government has started its first steps following international regulations and experiences from developed countries in terms of green port strategies, however, only little research has addressed the situation in China. Lirn (2013) applied analytic hierarchy process (AHP) based on a questionnaire to weigh the importance given by Chinese port stakeholders to 17 green port indicators across five dimensions: air pollution management, noise pollution management, solid waste pollution management, liquid pollution management, marine biology preservation. Similarly, Chen and Pak (2017) applied a Delphi study to three major Chinese ports to analyse their green port strategies, according to 21 indicators across six categories: liquid pollution management, air pollution management, noise control, energy saving, ecosystem preservation, organisation and management. Both studies found that air pollution reduction was considered the most important goal by the stakeholders, but also that in recent years Chinese port stakeholders were also looking at other goals such as liquid pollution and energy reduction in port activities. Dong (2015) stressed the importance of new technology and innovation in pollution management, noise and CO₂ emission control, as well as educating port staff working to increase environment protection awareness and applying successful strategies from foreign ports where appropriate. Wang (2016) collected data in Tianjin Port and Qingdao Port respectively to analyse their energy consumption and safety issues, showing that green port actions are currently focused on activities within the port and not on the inland transport system. Liu and Yu (2011) identified the challenge in Chinese green port management and particularly noted that the environmental dimension of the intermodal system is under-researched.

In terms of international comparisons with China, Lam and Notteboom (2014) compared the green port tools adopted in four countries including China and revealed that, while some ports are mature in exercising prevalent environmental standard regulations while encouragement methods like incentives and support from the

government, collaborative action with other public agencies and the private sector need to be explored in developing countries. Therefore, this thesis will build on Lam & Notteboom (2014)'s work by exploring the current situation in China.

5. Case studies of two Chinese ports

5.1 Introduction

In section 4.2, the overview of Chinese port system has been summarized to describe the general backgrounds of two case ports. This should enable a better understanding of interviewees' responses in analysing processes. In this chapter, more factual information about Ningbo-Zhoushan Port (5.2) and Dalian Port (5.3) will be given, in order to answer the question of the extensiveness and effectiveness of green port strategies under the Chinese policy background, and how Chinese green port tools work in the subjects, any difficulties the port encountered and the interviewees' suggestions to improve and further develop such measures. Detailed discussion on the results presented in this Chapter will be given in Chapter 6. The positions of two case ports are shown in figure 5.1.

The overview of each case study port is aggregated from material collected from interviewees and also extracted from notes made during the interview. After that, the qualitative responses from 7 overarching interview questions for each case study port were detailed analysed.



Figure 5.1 Location of Ningbo-Zhoushan port and Dalian port.

5.2 Overview of Ningbo-Zhoushan Port

Ningbo-Zhoushan port is located in Zhejiang Province, the central part of the coastline of China. Its hinterlands cover most cities southern to Shanghai in Yangtze River Delta where is heavily industrialized with advanced transport infrastructure and famous for labor intensive consumer goods, textiles, metals, glass products, furniture, motor and bicycles, electronics, construction materials, paper products etc. Large number of factories with high demands of import and export business shaped Ningbo-Zhoushan port one of the busiest ports in the world in 2016 (shown in table 5.2).

Table 5.1 Top 50 world container ports (source: (Lloydslist.com., 2016))

Rank	Port	Volume 2016 (Million TEU)
1	Shanghai, China	37.13
2	Singapore	30.90
3	Shenzhen, China	23.97
4	Ningbo-Zhoushan, China	21.60
5	Busan, South Korea	19.85
6	Hong Kong, S.A.R., China	19.81
7	Guangzhou Harbor, China	18.85
8	Qingdao, China	18.01
9	Jebel Ali, Dubai, United Arab Emirates	15.73
10	Tianjin, China	14.49

According to the development vision and detailed plans on regional port system from the State Council in 2010, nation's investment would focus on port infrastructure such as iron ore and crude oil transportation system, hinterland upper stream construction in the Yangtze River Delta to equip NingboZhoushan as a key hub port. Holding affluent hinterlands and constantly improved intermodal system, Ningbo-Zhoushan Port was named to play a key role in "21st Century Maritime Silk Road" initiative. Up to now, the port has the highest completed transport modes in China in terms of waterway, highway, railway and pipeline transport, and has launched 7 sea-railway intermodal transport trains, 12 "dry ports" throughout the main south-west and central parts of country. The radial outreach of the port has been improved substantially and has continuously expanded to midwest, Xinjiang, Xi'an and other northwest territories.

The whole port consists of 19 port districts and more than 600 production berths including the super-large deep-water berths that able to call the largest container ship in the world. The main manual deep-water channel is 22.5m depth which has ability to navigate 300,000 dwt vessels and by the end of 2015. Ningbo-Zhoushan Port has 236

container shipping routes including 118 ocean-going main routes, with average monthly sailing of approximate 1400. It is an important member in the China's highest economic developmental Yangtze River economic belt equipped with completed port facilities handling all kinds of cargos with high-efficient service which has the highest level for bridge crane stand-alone operating efficiency of 235.6 units per hour. In 2014, the port ranked the first in average on-berthing efficiency for operation of MSK ships with capacity of 18000-TEUs in the world. The unique regional geography allows NingboZhoushan port squarely face to the East Asia and the whole pacific rim, hence it as a reasonable start point for ocean-going transport from coastal area of China to America, Oceania and South American, and also, it is the ideal port for the distribution center from China's coastal areas to the continents by sea. All of these advantages make it become one of the busiest ports in the world.

In the 'Overall Planning of Ningbo-Zhoushan Port' published by Ministry of Communication in Chinese '13th Five-year Plan', in 2017, it classifies the 19 port districts in three category by ports' roles in regional development: the main port areas consist of nine districts focus on comprehensive transportation; five important ones will concern more on ocean industry; the remaining five general districts are mainly serving local economy development. It is going to build Ningbo-Zhoushan port as an important member of the Shanghai International Shipping Center, concentrate on transit of bulk energy products and raw materials, container transport rail-sea intermodal transportation and Zhoushan river-sea transportation center construction. In recent years, the development of NingboZhoushan Port has been well recognized by central government and all sectors of the society and has been successfully enlisted in World's 4th largest Container Ports in 2015 and kept its rank in 2016 (Lloydslist.com., 2016).

The Ningbo port management institution first settled as 'Zhejiang Province Shipping Administrative Bureau, Ningbo Office' in 1949, in charge of open sea and inner river

shipping administration and since then the port was under the government of Ningbo City Council (Portnbzs.com.cn., 2017). Until 2004, Ningbo Port Authority separated government functions by setting up Ningbo Port Group Corporate Limited in charge of port operation planning, procurement, infrastructure enhancement and development, finance and others. Zhoushan Port was under the municipal of Zhoushan City Council since 1987. Due to the disturb from institutional factors and inter-port competition, in 2006, the Port of Ningbo was merged with the neighbouring Port of Zhoushan to form a combined cargo-handling center in order to increase the attractiveness of Yangtze River Delta gateway and enhance their competitive advantage by co-ordination (Jinggai, 2013). Finishing in 2015, the two port companies have been placed under Ningbo-Zhoushan Port Group, whose ownership was shared between Ningbo and Zhoushan branches under the State-owned Assets Supervision and Administration Commission leading.

After 2002, ports' institutional framework in China witnessed large scale decentralization, the ports used to be directly controlled by the National Ministry together with local governments were transferred to the corresponding local governments' administration. The port organizations were split into administration and corporation for port management. Port administration at the municipal level is to govern all the ports within its jurisdiction boundary while the corporations could retain certain proportions of the profits and use the funds for port development and innovation projects (Qiu, 2008). Based on description from of Ningbo-Zhoushan Port Co., Ltd's website, Ningbo Port Group was set up in 2004 and then establishes Ningbo Port Group Stock Co., Ltd with joint-stocks from China Merchants Holdings Company and other six companies in 2008. Ningbo-Zhoushan Port Co., Ltd, formerly Ningbo Port Co., Ltd is 100% owned by Zhejiang Port Investment Operation Group. After the integration of the other five port groups in 2016, all ports resources in Zhejiang province were owned by Zhejiang SASAC (State-owned Assets Supervision and Administration Commission) (Portnbzs.com.cn., 2017).

In demand of efficient port industry and initiative master plan for regional spatial harbors, the Company diversifies the ownership of port industries by attracting investment from various sources. Ningbo-Zhoushan Port Co., Ltd takes the responsibility of its 19 port clusters' management (mainly in Ningbo Port and Zhoushan Port) with a total of 30 subsidiaries in port-related value-added logistics (cargo handling, cargo transport, and import and export business) and terminal operation. Some of the subsidiaries are directly involved in container cargo handling, crude oil and iron ore operation such as Ningbo Port Co., Ltd. Beilun Second Container Terminal Branch, Ningbo Daxie China Merchants International Container Terminal; some are terminal management, pilotage, tally service and freight forwarding companies like The Quhuang Harbor of Zhoushan Development Construction Ltd, Ningbo Port International Logistics Co., Ltd. All of the subsidiaries are either wholly owned by Ningbo-Zhoushan Port Co., Ltd or joint ventured with domestic corporations (mostly state-owned corporations) or foreign companies such as Maersk while Ningbo-Zhoushan Port Group as the largest shareholder.

The subsidiaries of Ningbo-Zhoushan port company are listed in table 5.2.

Table 5.2 Subsidiaries of Ningbo-Zhoushan port company. (source: Zjseaport.com. (2019))

Ningbo Port Group Beilun Third Container Co., Ltd.	Ningbo Zhoushan Port Zhoushan Port Co., Ltd.	Ningbo Ocean Shipping Co., Ltd.	Ningbo Port Container Transportation Co., Ltd.	Nanjing Mingzhou Terminal Co., Ltd.
Ningbo Zhoushan Port Co., Ltd. Beilun Ore Terminal Branch	Wenzhou Port Group Co., Ltd.	Ningbo Foreign Wheel Tally Co., Ltd.	Ningbo Port Information Communication Co., Ltd.	Taicang Wanfang International Terminal Co., Ltd.

Ningbo Zhoushan Port Co., Ltd. Beilun Second Container Terminal Branch	Zhejiang Harbour Jiaxing Port Co., Ltd.	Ningbo Port Railway Co., Ltd.	Zhejiang Yiwu Port Co., Ltd.	Zhejiang Yigangtong E-commerce Co., Ltd.
Ningbo Beilun First Container Terminal Co., Ltd.	Ningbo Dagang Pilot Co., Ltd.	Ningbo Port International Logistics Co., Ltd.	Zhoushan Yuzhou Container Terminal Co., Ltd.	Suzhou Modern Container Terminal Co., Ltd.
Ningbo Zhoushan Port Co., Ltd. Zhenhai Port Branch	Ningbo Meishan Island International Container Terminal Co., Ltd.	Ningbo Port International Trade Co., Ltd.	Taicang Wugang Terminal Co., Ltd.	Ningbo Port Shipping Freight Forwarding Co., Ltd.
Ningbo Zhoushan Port Co., Ltd. Oil Port Turning Branch	Ningbo Daxie Merchants International Terminal Co., Ltd.	Ningbo Gangqiang Industrial Co., Ltd.	Zhoushan Yuhuang Port Development and Construction Co., Ltd.	Taicang International Container Terminal Co., Ltd.

Ningbo Harbor Bureau was incorporated into Ningbo Municipal Government provide regional port development plans and direct the Company to carry out the layout plan promulgated by Ministry of Communications, supervise the Port Group consist itself with the national plan. It carries out the following functions:

- Administration, and supervision of commercial organizations operating in the port industry;
- Regulation and planning, with respect to industry standards, market rules, pricing rules and guidelines;
- Supervision, levying the dues for road, waterway, port fixed assets and transportation tolls;

- Development, provision and maintenance of public construction, in charge of the safety of port construction projects and port activity.

Thus, although Ningbo-Zhoushan port has split its administration and corporation functions, the Company only carries out operations of daily business running while Ningbo-Zhoushan municipal port administrations in terms of Maritime Port Bureau, Port Authority and municipal Maritime Safety Administration are in charge of regulation implementation, planning making and other governmental procedures.

As regards regulation, according to Port Law of the People's Republic of China, the municipal Maritime Port Bureau is in charge of the implementation of national laws, regulations and rules and formulate relevant regulations on port management in the province. The function of the Maritime Port Bureau includes preparing port layout planning, overall planning, shoreline utilization planning, and implement unified administrative management of port shorelines, land areas, and waters. Then, supervise and manage the safe production and environmental protection of the port. For the financial issue, Maritime Port Bureau is in charge of state administrative expenses, supervising the prices and managing the operating expenses items of port enterprises. Responsible for coordinating the port operations and collection and transportation of national key materials, military materials and rescue and relief materials.

The Maritime Port Bureau is one of the government sectors in the Chinese governing system and generally subordinate to the department of transportation in each city. Therefore, the municipal port administration has the responsibilities to line the duty of port management stated by the Transportation department of the state council which includes developing port development strategies, guidelines, policies, regulations and supervision according to national economic and social development needs (Zjzfw.gov.cn. (2019)).

The function of Port Authority in China also includes the implementation of the Port Law and other laws and regulations governing port administration, the provincial and municipal guidelines, policies and regulations on port management, and formulating port industry rules, port regulations, annual plans and management methods, and organizing implementation. It compiles (revises) the overall planning of local ports, and implements unified administrative management structures on the shoreline, land and waters of ports. Supervise the port construction market order according to the Port Law, review and approve the port facility construction project, and participate in the completion acceptance of the project construction project.

In management aspect, the Port Authority is in charge of implementing the port operation permit system according to law. Review and approve the business applications submitted by enterprises in port passenger transportation services, loading and unloading, porting, warehousing operations, port tally operations and port tugboat operations in the port area. Besides, it takes the responsibility of supervising and inspecting the safe production of ports, formulating emergency plans for port dangerous goods accidents that may endanger public interests, emergency evacuation and rescue plans for major production safety accidents, and planning for preventing natural disasters, and establish and improve port production safety accidents, emergency rescue system.

In financial sector, the Port Authority will collect and levy national administrative fees and related fees in accordance with regulations, supervise and manage the operating charges and prices of enterprises in accordance with the provisions of relevant laws and regulations. It also has the right to impose penalties on units and individuals that violate port planning and construction, port production and operation regulations, and inflict damage on port public facilities.

The obligation for municipal Maritime Safety Administration including propagate and implement relevant national laws, regulations and policies, be responsible for organizing the implementation of waterway traffic technical specifications, and be responsible for the city's waterway traffic and port shoreline administrative law enforcement and supervision and inspection. It is responsible for compiling the city's waterway transportation and port and local waterway development plans, compiling and planning and implementing the annual plan for the construction and reconstruction (conservation) of the maritime supervision, ship inspection, waterway management, and port navigation management. Responsible for water traffic safety supervision, preventing cargo ships from polluting waters, supervising and managing ship safety production conditions and water transportation enterprise safety management system, managing water traffic navigation order and navigation environment, demarcating and managing routes, prohibited areas, traffic control area, anchorage and safe operation area. Responsible for the administrative permission of underwater and underwater construction operations, monitoring the navigation status of ships in navigation waters and important port enterprises, organizing water emergency search and rescue, managing shipwreck salvage, management and release navigation.

The Maritime Safety Administration is responsible for the administrative management of local waterways in the city, responsible for reviewing the technical standards for navigation of navigation channels, and participating in the coordinated utilization of water resources. Take the responsibility of the administrative management of the port coastline of the city, approving the port construction of the port, implementing the administrative license and safety supervision and management of the port production.

It can be seen from the obligations of three departments that the port as an enterprise does not have the rights to build any infrastructure in the port area without permission from them, or cannot operate any commercial activities that not listed by the three department. The port environmental issue has been assigned to the three departments

and this division of responsibilities (along with many other regulatory responsibilities) may be the reason why greenness regulations issued by State Government could implemented much better at in port activities.

In spite of the port resources are managed by Zhejiang Province which allows local government has more administrative and financial sovereignty, the port layout plan is still controlled by Ministry of Communications. The deviation may rise between planning and operation. As the cargo handling facilities such as crane, trucks and warehouses are not owned by municipal port administration, and that they belong to port corporation which has a wide range of shareholders. Therefore, the regulations from municipal department for instance, environmental protection tools the Company or terminal operator may reluctant to do so.

5.3 Overview of Dalian Port

Dalian port locates in the head of Liaodong Byland, Liaoning Province. Its position is the entrance of Bohai Bay, feeder ship service between Dalian port and eight other ports along Bohai Bay makes it an ideal export and import port for the Three Northeastern Provinces of China (collectively, Heilongjiang Province, Jilin province and Liaoning Province). Dalian is an important node on Asia-Europe Land Bridge. More than 98% of foreign containers to three north-eastern provinces are transferred in Dalian port. As the starting point undertake sea-rail transportation of containerized goods from Japan, Hong Kong, Southeast Asia etc. to Europe via Russia (Ye, 1992), now there are 50 liner routes running every week from Dalian passing the three northeastern provinces to Russia and east Mongolia (Tu, 2017). Outwardly, Dalian and Japan, Korea are separated by sea and it is the first choice for maritime trade of North Korea in the long way. Since Japan actively in international industrial transfer, high export demand in Mongolia and energy exploitation hold by Russia, Dalian port become an international shipping center in northeast Asia and play a decisive role in increasing the

attractiveness of Bohai Bay gateway. As a consequence, in April, 2017 Dalian Free Trade Zone was put into force, advantage of Dalian as an international hub port is gradually emerged.

The history of Dalian Port can be tracked back to beginning of 19th century when it was the biggest port in north-east Asian. With the development of other ports, Dalian port has lost its competitiveness slightly between the counterparts such as Yingkou Port and Dandong Port. Geographical factor should be taken into consideration to find out the reason behind this. The distance between Dalian and Yingkou is less than 200 kilometre but Yingkou Port is closer to the mainland. Dalian Port has its limitation owing to the geographical location, most cargo flows come from north and south directions. As the cost of road transportation increased gradually and ended as several times higher than sea transport, Yingkou Port became the ideal export port for cargo coming from deep hinterlands that used to choose Dalian as they provide similar service type. In this case, Dalian port working initiatives to open new way to attract preference of its hinterlands. For example, operating block train by chartering the railway from Dalian to main terminal cities (Shenyang, Ha'erbin and Changchun) and cooperate with state owned or private owned enterprises for adequate and stable supply in containerized cargo. Now, Dalian Port has established a mature sea-rail intermodal service system among Japan, South Korea, and European countries.

Because of relatively enclosed territorial, lack of cooperation and unhealthy competition in cargo flow acquirement in crossing hinterlands between sea ports would weaken the economy in each port and then local economics. In order to mitigate cut-throat competition pressure and avoid re-construction in adjacent area, Liaoning province will form a new company to run its ports (Chinadaily.com.cn., 2017), and State-owned China Merchants Group will purchase a controlling stake—in the latest example of the government's intensified efforts to integrate the nation's ports and

increase their efficiency. The restructuring will center on the province's two biggest ports, Dalian Port and Yingkou Port, and there will be a move to integrate the operations of all the ports. According to the framework agreements, the establishment of the new company and the wider mixed ownership reform is expected to be completed in the current year and the integration of other port operators would be finished by the end of 2018.

6. Results and discussion

6.1 Introduction

This chapter will detailed analyse the results gathered from case studies in Chapter 5 centred on the green port strategies adopted in each port. In section 6.2.1, information derived from interviews are listed in a SWOT matrix (table 6.1) to provide a clear summarization. As noted in the methodology, employing of the SWOT enabled the underlying critical factors in the development of green port strategies to be identified. These are shown in table 6.2. This is then followed by a discussion on comparison answers in table 6.2 to explain the reasons behind each answer in section 6.2.2 to 6.2.4. Section 6.3 attempts to generalize the findings to most Chinese ports. The chapter ends with an outline of three possible scenarios, one based on economic factors, one on policy factors and one on technical factors, regarding the possible future development of green port strategies in China.

6.2 Green port strategies adopted in each port

6.2.1 Summary

In order to summarize and draw out the key information collected from the interviews, table 6.1 presents a SWOT matrix under the sub criteria of ship emission, port activities and port hinterland transport system of each port.

Table 6.1 The strengths, weaknesses, opportunities and threats in Ningbo-Zhoushan port and Dalian port to achieve green port in three criteria.

		Strengths	Weaknesses
Ningbo-Zhoushan port	Ship emissions	<ul style="list-style-type: none"> ▪ Has two terminals equipped with shore-power supply system. ▪ The ECAs that include the port was already took into force in 2016. 	<ul style="list-style-type: none"> ▪ Lack of incentive measure to encourage emission reduction on incoming vessels. e.g. incentive based on EEDI. ▪ Lack of support in the implementation and operation of shore-power supply system. ▪ Lack of compulsory measure on ECAs enforcement. ▪ Lack of technique support to promote shore-power supply. ▪ Lack of regulation on in port ship emission.
	Port activities	<ul style="list-style-type: none"> ▪ Already organized port activities following the criteria that listed in China Port Law. ▪ Employing LNG vehicles in port activities ▪ All RTGs in the port area are powered by electricity. 	<ul style="list-style-type: none"> ▪ Did not employ renewable energy in port activities.
	Port hinterland transport system	<ul style="list-style-type: none"> ▪ Has been selected by Ministry of Transport in the intermodal demonstration projects in 2016. ▪ Has advanced railway and road connection comparing to other ports in Zhejiang province. ▪ Has well container handling capacity for rail transportation. Every year could be over 1.5 million. 	<ul style="list-style-type: none"> ▪ Less container cargo flow forward to or from far hinterland cities. ▪ The price of container railway transport is high. ▪ Capacity of railway terminals in its inland cities are not enough for large cargo flow. ▪ Type matching issue of containers between railway and seaway transportation may

		<ul style="list-style-type: none"> Has establish several dry ports in its hinterland cities. Collaborating with railway operators to develop intermodal services. Has financial support from local government to promote sea-rail intermodal transport. 	reduce the frequency of its transportation system.
Dalian Port	Ship emissions	<ul style="list-style-type: none"> Has two terminals equipped with shore-power supply system. Has own the State annual award funds for the use of on-shore power supply by ships in port in 2016. 	<ul style="list-style-type: none"> Lack of incentive measures to encourage emission reduction on incoming vessels. e.g. incentive based on EEDI. Lack of support in the implementation and operation of shore-power supply system. Lack of compulsory measure on ECAs enforcement. Lack of technique support to promote shore-power supply. Lack of regulation on in port ship emission.
	Port activities	<ul style="list-style-type: none"> Already organized port activities following the criteria that listed in China Port Law. 	<ul style="list-style-type: none"> Cargo handling equipment and container trailer trucks are old and need large investment to retrofit. The port is located in mountainous terrain where it is difficult to transport heavy containers during transfer between different port districts using LNG powered trucks.

	Port hinterland transport system	<ul style="list-style-type: none"> Has been selected by Ministry of Transport in the intermodal demonstration projects in 2016. Has establish several dry ports in its hinterland cities. Collaborating with railway operators to develop intermodal services. Has well container handling capacity for rail transportation. Every year could be almost 2.5 million. 	<ul style="list-style-type: none"> The main type of containerized cargo are heavy goods and difficult to be transported by LNG trucks owing to technical shortage and geographies of the port. Type matching issue of containers between railway and seaway transportation may reduce the frequency of its transportation system.
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		Opportunities	Threats
Ningbo-Zhoushan port	Ship emissions	<ul style="list-style-type: none"> The state government will introduce more stringent measures on ship emission control in the future. New regulations on equipment for on-shore power supply services both on ship-side and shore-side should be promoted in the near future. 	<ul style="list-style-type: none"> Ship owner may reluctant to following the regulations owing to high costs without any incentive measures.
	Port activities	<ul style="list-style-type: none"> New regulation on trucks that entering port area may be put forward in the future. 	<ul style="list-style-type: none"> Implementation of renewable energy in port area may face barriers from other subjects, particularly economic factors.
	Port hinterland transport system	<ul style="list-style-type: none"> Has policy and financial support from state level to develop sea-rail intermodal transportation in the following years. Newly opened railway lines which will attract more cargo flow. 	<ul style="list-style-type: none"> Competition from adjacent ports such as Shanghai. The price of container railway transport is high.

		<ul style="list-style-type: none"> ▪ New dry port could be under the management of port company. ▪ New government cooperative relationship between port city and hinterland cities. ▪ The release of comprehensive transportation standards for container production, construction and technical requirements between different intermodal service providers will solve container type matching problem between varying transportation modes. 	<ul style="list-style-type: none"> ▪ New opened hinterlands may be overlapped with other ports’.
Dalian Port	Ship emissions	<ul style="list-style-type: none"> ▪ The ECAs that the port belongs to will come into force in 2018. ▪ The state government will introduce more stringent measure on ship emission. ▪ New regulations on equipment for on-shore power supply services both on ship-side and shore-side should be promoted in the near future. 	<ul style="list-style-type: none"> ▪ Ship owner may reluctant to following the regulations owing to high costs without any incentive measures.
	Port activities	<ul style="list-style-type: none"> ▪ New regulation on trucks that entering port area may be put forward in the future. 	<ul style="list-style-type: none"> ▪ High retrofit investment may cause heavy burden on the port finance issue. ▪ Implementation of renewable energy in port area may face barriers from other subjects.

	<p>Port hinterland transport system</p>	<ul style="list-style-type: none"> ▪ Policy and financial support from state level. ▪ New opened railway lines which will attract more cargo flow. ▪ New dry port may could be under the management of port company. ▪ New government cooperative relationship between port city and hinterland cities. ▪ The release of comprehensive transportation standards for container production, construction and technical requirements between different intermodal service providers will solve container type matching problem between varying transportation modes. ▪ The port may be will integrated with adjacent ports to avoid vicious competition in the near future. 	<ul style="list-style-type: none"> ▪ The price of container railway transport is high. ▪ New opened hinterlands may be overlapped with other ports.
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Examination of the SWOT matrix strongly indicates that the weaknesses and threats tend to far outnumber the strengths and opportunities. In the course of any major change, particularly one that comes at an economic cost, such an outcome is almost inevitable. Many of the weaknesses however are in areas of knowledge or more generally technological expertise, and hence development of these areas could be turned into a 'strength' as one or both ports could potentially become industry leaders in these areas, and hence strengthen their market position in the future as (or if) environmental controls become more stringent. The key strengths identified, particularly the issue of dry ports, represent major developments in the port industry in China and potentially these are in areas where economic drivers (the need to increase port accessibility) are consistent with more general environmental concerns (the need to transport higher loads increasing the competitiveness of rail). Therefore, a SO strategy should be the first choice in their development plan. Although each port has its own weakness, it can seize the opportunity both politically and economically and take WO strategy in the future. Possible economic, policy and technical scenarios will be discussed in section 6.3 after explaining the findings.

After noting the characteristics of the case ports, the findings of exact green port tools applied in the two ports are then compared with developed countries which is listed in Table 6.2.

The table shows that neither port is very active in addressing shipping emissions, for reasons that will be discussed in the following section. Both ports are quite active in green strategies dealing with port activities, with the difference that Ningbo-Zhoushan Port has introduced LNG vehicles within the port area. Together with Dalian Port, Ningbo-Zhoushan Port also have invested in hinterland infrastructure and dry ports for intermodal transport. The reasons why these tools were selected and the others have not been attempted were explored in the interviews and the results presented in the following sections.

Table 6.2 List of application of green port strategies in the two ports

Focus	Green port strategies	NingboZhoushan Port	Dalian Port
Ship emissions	Penalty or incentive based on green performance of vessels (e.g. ESI, EEDI)	No	No
	Require slow steaming while on approach or in the port	No	No
	On-shore power supply	Partial	Partial
Port activities	Using cleaner power (electric or LNG) vehicles in port activities	Yes	No
	Developing renewable energy source in the port	No	No
	Waste management and recycling, including sewage, spills and ballast water	Yes	Yes
	Noise and vibration reduction in handling activities	Yes	Yes
	Dust control from bulk handling	Yes	Yes
	Ecosystem protection (marine habitat, wetland and coastal erosion)	Yes	Yes
Port hinterland transport system	Give discount on port dues and fees for shippers based on choice of modal shift	Partial	Partial
	Incentives and licensing for greener trucks	No	No
	Invest in hinterland infrastructure	Yes	Yes
	Collaboration with rail operators to develop intermodal services	Yes	Yes
	Invest in dry ports	Yes	Yes

6.2.2 Green port strategies for reducing ship emissions

Table 6.2 shows that neither of the ports are very active applying the possible strategies for reducing ship emissions. According to the interviews, one of the reasons for this phenomenon is ECAs in China are not admitted by the IMO therefore have no authority

over international vessels. As for pricing controls, there are no subsidies or other incentive methods from either of the port authorities to encourage voluntary actions adopted by ships to mitigate emissions in the port area such as switching to alternative fuels like LNG, nor have they applied compulsory requirements such as vessel speed reduction.

Even when a ship is at berth, on board auxiliaries have to be powered by electricity generated by a diesel generator to maintain performance. As a consequence, sulphide emissions is one of the most direct threats to the port environment when the vessel is in harbour. As an example, even a small cargo ship (about 6000 deadweight ton) still needs to burn 1 ton of diesel oil per day to maintain on board power systems during berthing. The fuel used in ships is mainly residual oil or heavy oil that under the classification of diesel oil. The sulphur content of heavy oil is 100 to 3500 times more than that of light oil. Therefore, the ship in harbour as well as the ship that approaching the port has strong connection to environmental threats.

It has been acknowledged that employing light oil could improve the performance of diesel engine during low speed and more important, light oil has lower sulphur content hence is more 'green'. However, the price of later one is higher than the former. With the OBOR goes deeper, green port management has gradually drawn more attention from Chinese policy maker. In 2016, Shanghai Port began to require the vessels that calling at the port using light oil (low sulphur fuel with sulphur content $\leq 0.5\%$) when they entering ECA (<12 sea mile) and during docking period (except for 1 hour after arrival and 1 hour before departure) following the "Pearl River Delta, Yangtze River Delta, Bohai Sea (Beijing-Tianjin-Hebei) Waters Ship Emission Control Area Implementation Plan" issued in 2015. On April 1, 2016, Ningbo-Zhoushan port applied this requirement followed by Dalian port on 1st January 2018.

When it comes to on-shore power supply, which has proved to be an effective ship emission mitigation tool in some ports, only two terminals in each port offer the possibility, but do not require vessels to use it. More terminals have not implemented the technology due to the very high costs of implementation

From the interview in Ningbo-Zhoushan port, a single set of construction of Low-voltage shore power equipment currently needs an investment of around 700 to 900 thousand yuan (\$100k to \$130k USDs) . The installation of a single set of high-voltage frequency conversion equipment needs to invest about 8 million to 10 million yuan (around \$1.2 to \$1.5 million USD). And such devices have a long depreciation period hence a very long investment ‘horizon’ over which the initial investment needs to be recouped. Based on current figures, then with the full consideration of depreciation charges, labour and cost of electricity, the port would lose about 5 to 25 yuan (\$0.7 to \$3.5 USD) in every KWH usage during the process.

Another challenge relating to cold ironing is the technical limitation, due to differences of voltage and frequency standards in China and other countries. For most international vessels the ship electrical system is powered by 60Hz, 440V/6.6Kv/11kV (low-voltage and high-voltage) while the line frequency in Chinese ports is 50Hz. Therefore, higher security guarantee and the installation of frequency converters are needed for Chinese ports to implement cold ironing, which increases the cost. Moreover, although the national vessels can use on shore power supply system directly without frequency conversion, most ships operating in inland waterways are not electrified and would need to make large investments to add this capability. However, ship owners are reluctant to do so without subsidies.

Although the national government strategy strongly recommends ships to use on-shore power during berth time, change fuel to low sulphur and use other equivalent methods to reduce ship emissions, there is no provision of incentives or compulsion on ports to implement these policies. The current “Law of the People's Republic of China on the Prevention and Control of Air Pollution” has established a total system for the control and licensing of atmospheric pollutants and an illegal system for excessive discharge of pollutants. However, this excludes pollutants discharged by diesel ancillary engine of in port vessels. In addition, the current “Sewage Pollutant Emission Standards” only set standards on discharge of oily sewage, domestic sewage and marine garbage of ships, and does not regulate the discharge of air pollutants from ships. Therefore, at present, China does not have exact requirements for air pollutant emission control of ships in the port.

Furhtermore, there is a lack of clear road map and timetable on promoting the use of on-shore power supply service in the port. Apart from subsidies, clear regulations and operation guidelines are required to first build up the market.

6.2.3 Green port strategies in port activities

Considering green strategies within the port area, results from the interviews show that Dalian Port is not implementing any of the possible strategy types, although NingboZhoushan Port is doing well in energy saving activities such as piloting the use of LNG trucks in the port area, changing the fuel supply of RTGs from diesel oil to electricity and using power saving bulbs in the lighting system. In the port, up to now over 40% of port owned container trucks are powered by LNG and each truck could save 25 tons of CO₂ per year. In addition, all RTGs in Ningbo-Zhoushan Port had been powered by electricity since 2012 and had saved almost 9.8 thousand tons of CO₂ per year compared with diesel energy.

Dalian Port reported that they faced several challenges in adopting any of these strategies. The first challenge relates to cargo type. The main type of containerized cargo in this port are heavy goods like commodity auto and spare parts, woodware and glass which makes it much heavier than light cargo with the same volume. Therefore, owing to current technical limitations, electric powered engines cannot meet the power take-off requirement compared to fossil fuelled vehicles. Moreover, Dalian Port is located in mountainous terrain where it is difficult to transport heavy containers during transfer between different port districts using LNG powered trucks because of low take-off power for heavy cargo containers. Finally, cargo handling equipment and container trailer trucks in Dalian Port are relatively older than that in Ningbo-Zhoushan Port as the former port has a longer history than the latter. Therefore, the authority in Dalian Port would need to invest more to retrofit its production system, which is challenging.

Besides clean energy usage, there is no evidence for renewable energy employed in either of the two ports for production activities. One interesting finding, is that there are wind power generators installed in the port area but are managed by local State Grid Corporation. The electric energy produced therefore is returned to the national power grid

and the port has to pay for it as any other customer. This is because the State Grid Corporation is a state owned enterprise and not under the control of municipal government, hence there are barriers in the cooperation process between port and State Grid Corporation.

From an overall perspective, some of the electricity used by a port are generated from wind power which belongs to clean energy, however the port receives no direct benefit in the clean energy implementation. As a consequence, there is no incentive mechanism to develop such measures further..

Since the ‘Guideline for Green Port Rating System’ performed by China Ports & Harbours Association has been tested at major ports in China (Chen and Pak, 2017), more criteria under green port practices were provided for ports to apply. According to the interview results, both ports are active in managing their waste and recycling, as sewage and solid waste from calling ships is managed by qualified industries and a quarantine centre. Contingency plans are in place at both ports for oil spills and the ports cooperate with staff from the local transportation department to minimise damage to the coastal area. Noise and vibration reduction strategies have also been adopted for handling activities to protect the health of port workers and for ambient noise reduction. Both NingboZhoushan Port and Dalian Port have implemented procedures for dust control, such as water spraying to clean the dust in the air, using grabbers and bucket chains for unloading vessels and when using the belt conveyor it has been equipped with a mobile enclosure in order to reduce dust emissions. In order to protect the marine habitat, an environmental assessment is operated in both port districts to monitor any threats to the environment and coastal erosion.

The green port tools have received high responses in port activities criteria. This is mainly because they are listed in the Port law of the People's Republic of China, Production safety law of the People's Republic of China and Environmental protection law of the People's Republic of China (more are listed in table 6.3), and any violation will face heavy penalties. There may be some supplementary regulations in different individual ports but not listed here.

Table 6.3 Chinese regulations on port.

Port law of the People's Republic of China
Urban and rural planning law of the People's Republic of China
Emergency response law of the People's Republic of China
Production safety law of the People's Republic of China
Environmental protection law of the People's Republic of China
Air Pollution Prevention and Control Law

There are requirement and also guidelines on treatment of oily sewage, treatment of toxic washing water, treatment of domestic sewage, ship garbage disposal, dust and noise control etc. inside of these regulations.

6.2.4 Green port strategies in the inland transport system

The green port tools that have been employed most by the two ports relate to greening the inland transport system. Both ports have provided incentives in terms of encouraging shippers to use intermodal transport, such as giving discount on inspection fees, extension of free service time and providing priority on shipping schedules for sea-rail containers but not penalties or discount on port dues as these are out of the rights of port authorities in the context of China.

The successful implementation of these green port tools is largely as a result of policy support. In 2016, the Ministry of Transport and the National Development and Reform Commission determined the first batch of multimodal demonstration projects. The selected project will get special support policies and measures. Dalian Northeast Asia International Shipping Center “Asia-Pacific – Northeast Region” channel container sea-rail public multimodal demonstration project and ‘Ningbo Zhoushan Port-Zhejiang-Xiangxiang’ Container Seal-rail Multimodal Transport Demonstration Project were listed in the roll.

After one year, in 2017, Ministry of Transport, the State Railway Administration and the China Railway Corporation jointly issued the “13th Five-Year Port Collection and

Distributing System Construction Plan” to speed up the last mile accessibility of railway and road connection to the port. During the "13th Five-Year Plan" period, it is planned to support the construction of a 2,000-kilometer collection and distribution railway and a 1,300-kilometer collection and distribution road.

In order to complete the task that as a demonstration project, the port needs a an efficient railway transport corridor including tracks and terminal to carry the cargo from hinterlands. Both ports have been actively in investing in hinterland intermodal infrastructure and collaborating with rail stakeholders. The ports have worked with the local rail authority in their area, under the umbrella of the national authority China Railways Corporation (CRC) to get lower freight rates and more flexible train schedules for big consigners. In addition, both ports authorities have invested in rail track infrastructure connecting the port district directly with the national rail network. And they have also invested in employing new techniques to enable containers unloaded from ships to transfer directly to rail wagons subsequently transported by port-owned locomotive to national rail marshalling yards. In order to support the investment in hinterland infrastructure and improve intermodal connectivity within the port, both ports have also invested in retrofitting of container handling equipment and container yard expansion. New RTGs with higher operational capacity for rail containers were purchased, and expanded searail container terminals are currently under implementation by both ports. According to the interviewees, maximum container handling capacity for rail transportation per year in Ningbo-Zhoushan Port could be over 1.5 million and almost 2.5 million containers in Dalian Port.

After the construction of ‘hardware’, the port need large and stable cargo flow to support the running of sea-rail intermodal train. Both ports have also been active developing dry ports in port hinterlands and cooperating with main production factories. The dry port provides customs clearance, warehousing, consolidation and storage services to speed up container turnover rate and simplify total logistic processes. Moreover, the dry port has advantages in providing customer-centred services for local factories that usually have fixed demand for export or import business of container goods and, therefore, are able to consolidate steady cargo flows for the seaports.

Nevertheless, the interviews revealed that bottlenecks and challenges are increasingly prominent especially in inland transport system integration progress, such as type matching, collaboration among logistics partners and shortage of initiative strategies. This can be further illustrated in the issue of matching sea and rail container types. Because of varying standards between China's railway and international deep-sea containers such as tensile strength, installation criterion and sizes, rail containers cannot be employed in ocean shipping. Therefore, all the cargo needs to be transloaded from railway bureau owned container to an ISO maritime container before being loaded on the ship, which adds to the total cargo handling time and costs. Similarly, there is a mismatch between the container and cargo type. China's supply of railway containers able to transport bulk cargo (grain, iron and crude oil) is limited.

Therefore, a standardization of transportation equipment between more than two types of transportation is critically needed. Besides, to improve the quality and level of intermodal integrated transportation services, information interconnection and open sharing among different modes subjects are also important.

As is common in successful intermodal transport globally, sufficient distance is needed for intermodal to compete with road transport. Sea-rail intermodal transport is only costeffective over longer distances and with large volumes of cargo, however, the shipping demand in China from far distant hinterlands is insufficient. Owing to the geography of the country, all China's ports are located along the eastern coastline and most factories are built within 400km of the ports because cargo shipping has traditionally been based on road transport. And because of the development imbalance in China, export and import demands in western cities are currently very small. Currently the rail price is excessively high for consigner and logistic company without subsidies from the government.

From the organisational perspective, the Chinese railway operator is a public monopoly. Although the Chinese railway system experienced a radical reform in 2013 which separated commercial work and management function, there is still a long way to go from planned economy to market-oriented economy. The railway transport has its own standard lading bill which requires the consigners to send the shipping plan at least four

days before the required date which reduces the flexibility. In addition, the CRC is a state-owned company reporting directly to the central government and financed by the Ministry of Finance and regulated by Ministry of Communication (MOC) and State Railways Administration (SRA) (Jianxiang, 2017) and works in a monopolistic way. It builds station infrastructure and tracks funded by the government and seldom accepts investment from private capital which does not always align responsively to market requirements. The real situation from interviewees shows that inland rail stations do not have e-service system for cargo and some of them do not have capacity to handle forecasted number of containers. One option raised in the interviews is the possibility of a multilateral information sharing platform among segmented logistic service providers to facilitate message exchange. It is hoped that this could provide one integrated enterprise combining all logistics tasks together in order to lower freight expenses instead of outsourcing layer by layer.

6.3 Discussion

By comparing green port strategies adopted in developed countries with the results gathered from the two Chinese ports, it appears that Chinese ports (at least in these two cases) are actively improving the environmental performance of their activities inside the port in terms of waste, dust, noise, etc. but less so in terms of emissions reduction. The purpose of green port management is to promote the improvement of port ambient air quality. Therefore, local government's emission reduction pressure will be alleviated and the people living near the port will benefit. The port as a business entity, has strongly promoted the development of the local economy by attracting money flow to the local market. However, the environmental protection issue should not only be the responsibility of the port company, or the ship owner. In economic terms, both are acting to 'type', i.e. are profit maximising. Local government as the beneficiary from emission and pollution reduction should take measures to compensate the port. This could not only be through subsidies but also other initiatives or responsibility transactions, such as the development of better rail links, which may better meet both economic and environmental considerations.

They are both starting to work actively in the hinterland transport sector, while doing little in terms of incentivising action on ship emissions. While on one hand, it shows that Chinese ports still have work to do in order to be consistent with national macro-policies promoting a transformation from fossil energy-intense developments to sustainable development over the past 10 years, on the other hand these findings are consistent with the actions of many world ports.

As is common in most ports around the world, low priority for investment for upgrading costs is the primary barrier in the greening process of China's ports. The second barrier, and most relevant in terms of the lack of green port tools implemented for reducing ship emissions, is the reluctance to introduce charges for polluting ships or financial incentives for more environmentally friendly vessels. This might also reflect to some extent the limitation of the Chinese political context. In China, the supervision function of implementing international regulations such as ECAs, low sulphur fuel usage and ship retrofit for on-shore power supply are the responsibility of the Maritime Safety Administration of the People's Republic of China while the pricing methods in port policy fall under the management of central government and the respective provincial governments. As charges on polluting ships may result in a reduction of calling vessels hence affect the interest of the ports and the local government, this will be the last choice for the port authority without further pushing legislation from higher levels of government. The other operational difficulties faced by ports lie in implementation of shoreside power supply system due to the technology challenges which increases the cost.

Both ports were, however, active with environmental plans in the ports for dealing with waste, noise and dust, as well as plans for monitoring the local ecosystem. These are extensions of daily activities already happening at the port, hence basically follow the regulations in table 6.3. Therefore they are easier to achieve with lower investment. Air emissions is usually the main focus of green port strategies with other challenges such as noise and dust usually attracting less attention (Gonzalez-Aregall et al., 2018), but the findings show that these issues can be addressed without the need for major operational changes, investments and incentive schemes such as are commonly needed to reduce emissions.

The greater interest by the ports on hinterland transport strategies can be explained as a result of the policy of ‘developing sea-rail intermodal transport system’ which is consistent with ‘the Belt and the Road’ initiative in China’s 13th five year plan. This initiative concentrates on consolidating flows to fill the new containerized train corridors from China to European countries and further to improve the land transport network within China. The Chinese government have put forward the blueprint to set up transport hub centres in Chinese mainland cities along the corridor and upgrade the tracks between them. High capacity inland cargo transshipment terminals are also under construction. The ‘hardware’ such as cargo handling equipment and the transportation network are being improved, however, the ‘software’ in terms of strategies are still insufficient to motivate the port customers in shifting container freight from road to rail. The active involvement of ports in dry ports in recent years suggests some moves towards improving the inland movement of containers via increased integration between the ports, rail operators and inland terminal developers, but more work is needed on organisational processes to develop the Chinese intermodal network towards the models adopted in the USA and Europe (Monios and Wang, 2013).

Different geographical backgrounds between the two ports have also influenced the varying logistics practices in each port. Ningbo-Zhoushan Port has close hinterlands and most of them are located in the geographical scope of the same province, which has weakened the potential of sea-rail intermodal transport over short distance. Dalian Port has far distant hinterlands, however the cutthroat competition from nearby ports under the umbrella of the same government have acted as a brake on its inland transportation development. Integrating ports in adjacent area has been put into practice in several provinces by China Merchants Group and it is expected to complete the integration of Dalian Port with its nearby ports as a large port group by the end of 2018. Although the newly established Port Group Company is a continuation of the state owned enterprises (SOE), it reflects the determination of Chinese government to further carry out SOE reforms to eliminate excessive competition and duplication of resources and make it easier for one port authority to attract investors.

According to the description in section 2.3, one of the objectives of this research is to provide some suggestions to strategy makers to find suitable measures for similar cases in the future. Therefore, instead of viewing the problem merely on a transaction or firm specific level, the possible policy environment will be discussed in the following text. It is very difficult however to accurately predict one single course of future development, hence how the two ports could pursue opportunities and overcome weaknesses are presented through the building of 3 possible scenarios, the first generally based on economic drivers (port regionalization), the second through stricter policy actions (emissions controls) and the last through technical developments (harmonisation of standards). Each of these however may provide some insights into the policy requirements for the greater development of green port management in China.

Scenario I: Deeper port regionalization (Economic)

An intermodal transport chain requires the participation of many classes of stakeholders who need to work together, and these relationships can be managed under different kinds of agreements, with greater or lesser levels of collaboration and integration. From table 6.1, both ports have the threats come from high railway freight fee in reducing emissions and pollutants in port hinterland transport system criteria. In China, all the railway tracks are owned by Chinese government and mostly are operated by Railways Corporation (CRC), especially the arterial traffic. The inland railway terminals are also operated by CRC municipal branches, any market investment has to be proved by the centre CRC.

In the supply chain management environment, the port system gradually becomes spatially and functionally saturated with the development of the port collection and distribution network. The port at this stage will look to develop stronger connections with its hinterland as an intermediary node. Monios, Wilmsmeier. (2013) break this process down into three components, namely inland terminal development, inland logistics and collective actions, which represent the three aspects of port regionalization. In order to expand, the port needs to improve accessibility by either reaching further into its hinterland, and/or through port mergers under one single controlling authority, both of which constitute port regionalisation. This development on the one hand, can expand and extend the hinterland of the port, use resources of the hinterland as a reserve for port

development and let the port's production process and operation management reach a far wider area. On the other hand, the port could use the characteristics and advantages of its shoreline resources to reduce operating costs, improve loading and unloading efficiency and service level, hence to attract shipping companies to carry out transit business, strengthen the connection between ports and ports, and therefore form a stable transportation network within the region.

This would be a possible scenario in China's green port management system. Port regionalization could guarantee larger (and more regular) cargo flows from its spatially hinterland therefore increasing the demand for intermodal transportation. With the new type of agreements (or other cooperate documents) between port company and CRC and hinterland road haulage carriers, there will be more competitive intermodal transportation freight price in the transportation market.

However, the main sector that handle the port regionalization is still under widely research. Monios and Wilmsmeier (2013) show that developments driven by the public sector due to motivations of regional development are more prevalent in Europe, however, state involvement is becoming more common as a risk mitigation strategy in large intermodal schemes in the United States. Monios, J and Wang (2013) found that the inland port network emerging in China reflects similarities to patterns observed in more integrated networks such as Europe and North America. While the results indicates that lack of integration and the limitations of the port to act, elucidating why ports may experience challenges in controlling or capturing hinterlands through the strategies of integration that the port regionalisation concept suggests. For now in China the wagon and traction are still under strict control of CRC. Although the two case ports have established several inland ports in their hinterland, the ports have less assessment of inland transport traction.

One interesting finding in Monios and Bergqvist (2016) shows that 'it is more common to outsource traction than wagons' because the choice to invest in wagons has a more integrating dimension with other stakeholders as it heavily influences the efficiency of all operations, including not just the service but the marshalling and loading at the terminals. So it needs more research and attempt at Chinese port regionalization on operation level.

But given underlying economic trends, port regionalisation as a strategy presents both ports with good opportunities to promote their inland intermodal transport system and also in attracting foreign business and investment. It is expected the China Merchants Group will complete the integration of Dalian Port with its nearby ports as a large port group by the end of 2018, excessive competition and duplication of resources could be mitigated and make it easier for one port authority to attract investors and better co-ordinate port in and out flows with greater use of intermodal transport.

Scenario II: Introducing CO₂ emission obligation scheme at provincial level in China (Policy)

With the fast development in recent years, China has gained increasingly political, economic, and financial influence in the world. While at the same time, industrialized economy and large amount of fossil fuel burning has made China one of the main contributors to global greenhouse gas emission together with United States and India. Although the rise and fall of emissions is closely linked to economic development and the ongoing transition of its economy, China as a founding member of United Nations response actively in fighting with climate change. This was underlined by Chinese President Xi Jinping in the Intended Nationally Determined Contributions (INDC), where China pledged to peak CO₂ emissions by 2030 and strive to achieve it as soon as possible, cut its greenhouse gas emission unit of GDP by 60%-65% from the 2005 level by 2030, and increase the share of non-fossil fuels in primary energy consumption (Gao, 2016) (Dröge, 2014).

As shown in the 13th FYP released in 2016, climate change mitigation and local environmental improvement will be a whole-of-government priority focus on a transformation to non-fossil energy sources, electric vehicles developing and promoting China's green finance market. To enhance ecological protection, China will reform and improve the ecological and environmental regulation system, strengthen regulations over the use of natural ecological spaces, roll out a compensation system for ecological and environmental damage, and improve the compensation mechanisms for ecological conservation which improve the focus on initiative procedure for environmental protection. In addition, the Chinese government had already announced to gradually

establish a national carbon market as the cornerstones to tackle rising GHG emissions. From 2013 to 2016, in total eight pilot ETS were launched gradually by the National Development and Reform Commission (NDRC) including Shenzhen, Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei and Fujian (Ma, 2013) (China-ETS, 2018).

As described by (Ma, 2013), China's emissions trading scheme is unique because firstly, it is a bottom-up structure, with pilot projects carried out at the provincial and city level but with aspects of strong top-down command and control. Secondly, when China's ETS is fully operational, it will surpass the European Union's (EU) carbon market to become the largest carbon market in the world (Unfccc.int., 2017). Thirdly, unlike most other emissions trading systems in the world, the Chinese emissions trading system is not a product of democratic efforts or partisan struggle, but was created in a one-party state. Therefore the ETS could be a possible scenario. With specific regard to ports, these measures may create the need for co-ordination under a single regulatory authority (rather than the current situation where these responsibilities are divided between three different bodies) and this may lead to better advancement, co-ordination and policing of environmental issues in the sector. It would also increase the attractiveness of converting 'weaknesses' in this area to 'strengths'.

Nevertheless, at this stage the State Council is focusing more on power generation companies and other high emission plants that contribute large amounts of CO₂. In the long term however, the carbon allowances may assigned to provincial level because the local government is the beneficiary of cleaning port environment, and within these specific provinces port activities have a far larger (relative) impact on the environment than the sector in general at the state level.

In addition, environmental protection should be a social responsibility rather than an industrial charging measure. It is also important to establish a sense of social responsibility of industry enterprises in environmental protection, and guide the cultivation of the 'green port' awareness of the whole society. Enterprises should make their sustainability a core value driver of stakeholders, and then (ideally) use this as a marketing strategy to support the charging of higher prices in the market. In the UK, retail giant Tesco invests in special containers to transport its merchandise. While reducing

greenhouse gas emissions, road transport pressures and lowering transportation costs, its distinctive container with 'Less CO2 Rail' has also won extensive social support and brand reputation. If the Chinese government introduces mobilizing the enthusiasm of participating enterprises in the construction of green ports, and use its demonstration role of social responsibility to promote the sustainable development of China's port industry, it will provide more ambient conditions for green port construction. In this scenario, with the implementation of ETS as a guide to environmental protection, the consigner as well as the 3PL should work together to shift transportation methods towards less environmentally damaging supply chains. Therefore in this scenario, the shipping company may promote the usage of shore-power supply systems among its vessels, the State Grid might be delighted to cooperate with port company and other subjects that involved in intermodal transportation would notice the importance of greenness transport mode. There is therefore a strong possibilities that 'green' measures are developed that are far in excess of those required by future legislation.

Scenario III: unified transportation standards between different subjects involved in intermodal transportation and development of ITS. (technical)

In the 19th National Congress of the Communist Party of China, the ambition to build a strong transportation network has been written in the national development strategy. Establishing a transportation standardization management system to improve the efficiency in information exchange between different transport subjects is important to implement the construction of a strong transportation country. It could be speculated that the Chinese government realises that if levels of economic growth are to be maintained, then transport (technical) inefficiencies need to be eradicated.

In recent years, the State Council has been focused on deepening of the reform work of standardization work and the reform requirements of the large-scale system to build comprehensive transportation system. At present, railways, highways, waterways, civil aviation and postal services have formed their own standardized management systems. It is necessary to introduce transportation standardization management methods in the form of departmental regulations to build up a comprehensive transportation standardization management system which can provide cross platform IT systems and lead to greater

efficiencies through the employment of intelligent transport systems (ITS). As summarized in table 6.1, container type matching issues and diversification of bill of lading have impeded the mode shift from road only to sea-rail intermodal one. In addition, the efficiency of information exchange between different stakeholders (both nationally and internationally) is increasingly requiring more collective action.

Summery:

Apart from the above mentioned ones, there are more scenarios that the ports can make better use of their strengths and develop weaknesses into areas of strength. For instance, scientific and technological innovation and perfect evaluation system should be taken as driving force for realizing green port construction. Accelerating the development of technologies such as ship exhaust gas filtering devices, marine shore power equipment, shore power grid-connected technology, new energy pilot ships, high-energy LNG trucks, and energy-saving and environmentally-friendly transportation equipment, and further promoting new energy sources such as low-emission fuels and renewable energy are positive scenarios for the case ports' development. More criteria may refer to improvement of compatibility of container water and land transportation, transformation railway container handling technology, and enhancement of the timeliness of sea-rail combined transport.

However, there may be some exogenous scenarios such as if China's economic situation goes downward or turbulence in the port management system etc. For now most green port tools are strongly driven by top-down control in China so that if these scenarios do happen, the green port management system may has a strong threat to break down. But there may be some tools may not be affected such as LNG trucks using, port regionalisation and intermodal transportation in hinterland if the port deeply involved in the interest community. This may reflect the fact that rules that established by market and hence driven by economic considerations will have a stronger robustness to face outside threats.

7. Conclusion

7.1 Research summary

This thesis aims to understand the gap between developed and developing countries in green port strategy application by analysis of ports in China. First, a list of possible green port strategies applied in developed countries was summarised from the literature, although it is not the case that all ports in developed countries are applying those strategies as indeed many ports remain reluctant to increase costs for themselves or their customers the shipping lines. There has been very little work on developing countries, but the literature reviewed showed that developing countries are setting their first steps towards green port management strategies, but progress is slow.

Previous research on green ports in China has focused more on stakeholder perception, showing that air pollution was the main concern, followed by liquid pollution and energy management. Applying a list of potential green port tools used in developed countries to the two Chinese cases in this thesis showed that the two ports are most active in hinterland strategies and reducing noise, waste and dust within the port and not very active in reducing ship emissions. This situation is not dissimilar to ports in developed countries, who also prefer to act on the issues under their control, first actions within the port and second the intermodal connections, but least motivated to take action against carriers. However, the increasing pressure from society and government is leading to some interest in green strategies to incentivise less-polluting vessels in ports. Such pressures are much weaker in developing countries hence these strategies are even less likely to be selected by ports. In China, there is increasing government attention on this issue and policy goals established but not yet with the requirement that ports must follow. But this may be forthcoming in future. One limitation from the governance perspective is the complexity of governance scales from local to regional to national. But also, efforts are being made in China to streamline port governance (Notteboom and Yang, 2017). Thus, it may be that such reform is needed in developing countries before their ports are likely to engage in more proactive green port strategy application.

The results from the interviews showed that intermodal transport is the most active strategy in evidence, supported by collaboration of the parties in the logistics chain,

although this is also challenged by the vertically integrated and monopolised national railway system and lack of containerized cargo freight demand from the more distant regions of China. Some differences are specific to the individual ports, in that the varying cargo type in Ningbo-Zhoushan Port and Dalian Port have contributed to different implementation degrees of clean energy in port production activities. The individual background of ports must always be considered in making a long term development strategy by Chinese higher authorities in order to adjust the measures to local conditions.

Developing countries are moving forward gradually towards sustainable development. In order to learn from the experience of China, two key contributions can be highlighted: first, it revealed which green port strategies are being applied in Chinese ports, which can serve as a reference for future research to build on these findings. Second, the interviews uncovered the reasons why these strategies have been chosen rather than others, and points the way forward for further research on port governance in developing countries and particularly the role of governance in linking societal pressure for better environmental practices to the activities within the ports, such as has been increasingly evidenced in developed countries in recent years. These findings are relevant for ports that are experiencing high growth, and, meanwhile, facing challenges of environment protection.

7.2 Contribution to the literature

The contribution of this paper can be seen in threefold: firstly, apart from exploring what strategies have actually been implemented in developed countries, this thesis then splits them into ship emissions, port activities and hinterland transport. Although some studies have analysed the main environmental goals and concerns of Chinese port stakeholders, most in China were only focused on the economic environment. Liu and Yu (2011) hold the view that port is the driving force of global economics, green port development is the theory come out in the light of mitigating global environment deterioration and energy crisis. These two scholars have integrated the development and function of port together and focus on establishing highly efficient collecting and distributing system. They mention the problems in Chinese green port management while obstacles in how to update intermodal system were out of research. Dong (2015) stresses the importance of new

technology and innovation in pollution management, noise and CO₂ emission control. Educate the staff working at port to rise the environment protection awareness, absorb successful strategy from foreign ports are important as well. Liu and Yu (2011) and Wang (2016) collected data in Tianjin Port and Qingdao Port respectively to analyse their energy consumption and safety issue. This research divided the green port management in three sections in terms of environmental concerns come from ship emissions, port activities and the inland transport system. To the best knowledge of author, this research is the first one to carry out the green port study in China covering all the three sections.

Secondly, the use of semi-structured interviews enables the interpretation of the motivations and challenges related to each green strategy instead of listing out the tool's name solely.

Thirdly, it has enriched the current literature. In terms of international comparisons with China, Lam and Notteboom (2014) compared the green port tools adopted in four countries including China and revealed that, while some ports are mature in exercising prevalent environmental standard regulations while encouragement methods like incentives and support from the government, collaborative action with other public agencies and the private sector need to be explored in developing countries. This thesis has built on Lam and Notteboom (2014)'s work and the results has illustrated the current situation in China. This has provided valuable data for later researchers.

7.3 Reflection on the methodology and limitations of the research

The case study research is useful and important for all of the fields, especially for intensive study of complex social units consisting of multiple variables of potential importance in understanding the phenomenon. In this research, the case study of selected ports offers insights of operational challenges, policy limitations and preference of port manager in port sustainable development. It is anchored in real-life situations and the results are in a holistic view which were not mentioned in the other theoretical papers. In addition, case studies are one of the best ways to stimulate new and advanced research in the field, and the tentative hypotheses could help structure future research. The findings

of this paper have uncovered the contemporary situation in green port management of Chinese ports and advancing the knowledge base of current literature. In the case study, no attempt is made to assign frequencies to the linguistic features which are identified in the data, and rare phenomena receives the same amount of attention as more frequent phenomena. It enables more illumination ideas to be drawn especially if generalization is not one of the study's goals.

However, there might be some limitations existing in the case studies that firstly should be inability to replicate. Generally speaking, many case studies cannot be replicated and therefore, cannot be corroborated (UniversalClass.com., 2018). The findings cannot be extended to wider ports with the same degree of certainty that quantitative analyses can. This is because the findings of the research are not tested to discover whether they are statistically significant or due to chance (Atieno, 2009). Therefore, the conclusion in this paper is not in an absolute manner without additional studies.

In the narratives, the tellers' strategies can privilege their experiences. However, the narrative analysis itself cares more about the reasons behind the phenomenon. After stepping into the stage of interpretation and analysis, some social, cultural related factors which influence the interpretation cannot be avoided, without enough self-reflexivity, researchers with different backgrounds and orientations may inevitably distort the narrators' intended meanings (Mruck, 2003). Furthermore, it is very possible for the author to form a bias that can be for the subject, the way of the data to be interpreted. In this study, I keep in mind to be an outsider in order to interpret the results more objectively.

For this study, the main limitation should lie in the generalization of the results. Only two cases and seven field visits had been operated for the research question owing to the time limitation. Although the conclusion is carefully constructed with sufficient secondary data, there should be some more enlightens exist back of the reality which need additional studies. Furthermore, in the future study, the selection of interviewees should concern more factors such as gender, age, etc. to collect comprehensive data sets.

7.4 Suggestions for future research

Future studies following this research could focus on trying to find the reasonable incentive strategy that fit China's ports policy background to greener performance of vessels approaching the port and within the port area without losing traffic. More work on the shore side power supply system developing in Chinese ports, how the LNG bunkering and its trading related to green port developing are interesting topics as well.

Furthermore, the results show that ports are working hard on intermodal transportation tool as it received support from provincial and national policies, how the China's intermodal rail network supporting modal shift from road to rail for port hinterland flows and how much external costs could be saved by doing so could be another research direction. Using mathematical models to evaluate the contribution of policy measures to subsidize the internalization of external costs in terms of GHGs, accidents, noise and air pollutants and then to provide guidance to the decision makers for developing better intermodal transport strategy. After that, the research could go further to find out how Chinese ports cooperate with inland stakeholders to achieve more sustainable hinterland transport. Discussion on geographic economics on Chinese port management system and find out governance relationship between intermodal stockholders could also be referred.

The type matching issue between rail and maritime containers has been reflected from the case study. This indicates the technical investigation point and in addition, the new transportation contract between rail carrier and ship carrier and the empty container repositioning should also be developed if the local rail containers could be employed in global shipping.

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Appendix

Interview questions:

The interview question I designed are target to solve the first two research questions, follow the principle of semi-structured. Detailed text including a brief introduction of interview background and guideline questions with small questions I am going to ask during the interview are shown below:

Dear manager, I am DU Ke, first year PhD student from Edinburgh Napier University. I am doing research on ‘Comparison of green port strategy from developed countries to developing one’. Thank you for your time to attend this interview.

Under the background of sustainable development, green port strategies have become an important research topic around the world. It is a holistic strategy to manage environmental impacts from a) ship; b) port activity; c) hinterland transportation sectors. From literature review, industry news and port websites, among some main hub ports in European countries and America, green port strategy are employed and produce good results. Green port strategies in China started more recently, and the conflicts between economic and ecosystem in some area are sharp. Today I want to ask you some information about green port tools around three parts mentioned above adopted in port A(B).

Q1 about ship emission control, what tools have port A(B) adopted to mitigate GHG and air pollutant emissions? Such as pricing, monitoring and measuring, technical retrofit and market access control. What are the challenges in implementation, and how about the results? Could you use some examples to illustrate them?

Detailed questions that I am going to ask:

(From the policy angle)

- Does the port have a pricing strategy to promote control tools on ship emission? What will you do for the ship does not meet the requirements? If you have, is that works well? What is the problem in implementation? If not, will you adopt that? What problems exist?

- If the port monitoring and measure, or ask the information for amount of emissions of each incoming vessel? If yes, how about the result? If no, do you think it is a good idea and what is the problem in operation?
- Do you have policy terms (compulsory item) on allowable amount of sulphur or GHG emission in fuel that used by ship (such as scrubber)? How do you promote this item or do you have other method for same purpose?

(From the port infrastructure angle: on-shore power supply)

- How many terminals can provide on-shore power supply for ships? What incentives you have for terminals and ship to doing so? Is that possible to carry out in all terminals? What is the challenge?
- What about the ship sewage control? Do you have penalty on ship does not meet the standards?

Q2 what about the market reaction to higher emission standards? Will it do harm to number of incoming vessels and the business of port? If do exist, what will the port do to face with these problems?

If the carrier or the ship owner reluctant to do ship retrofits, what will the port do to encourage them? Is there any legislation state council (such as bonus)? What do you think the best way to solve the problem?

Q3 About control emissions and pollutant come from port activities, there is an authorized standard for green port evaluation system published by china port association and enforced in 2015. What have Port A (B) done to control emissions caused by port activities according to the guideline? What about the results of these tools? Could you illustrate with examples in terms of policy (strategy planning, specific grant, staff education), production (pollution control, waste reuse, energy saving and renewable and clean energy using), management (set specific people and project, environmental quality monitoring, restraints and incentives)

Detailed questions I am going to ask:

From idea angle:

- Did you release annual port sustainable development report? Both in Chinese and

English version?

- Did you set aside specific fund for green port construction every year?
- How did you educate the port staff about green port idea? What tools do you adopt to encourage the port staff and incoming vehicles about this idea?

From action angle:

- Does the port have specific policy about pollution and GHG emission standard on cargo handling equipment and incoming vehicles (especially for road mobility)? Do you have incentive and penalty strategy on it? What will you do if they do not meet the requirements?
- How do you use the waste energy in recycle way? To what extent do that save the energy (amount of energy saving)?
- What tools did the port adopt to control the emission from cargo handling equipment (such as retrofit the equipment, electrify the gantry)? What tools did the port adopt to save energy? Any positive results can be seen now?
- What have the port done to develop renewable energy? What is your future plan about that like how much energy supply can be replaced?
- About the clean energy usage, any methods the port adopt for incoming vehicles and cargo handling process? What is your future plan?

From management angle:

- Do the port has named specific people with professional knowledge and apartment to deal with green port construction? Is there any support for this project?
- Do you monitor the environmental index such as nitrogen oxide in port water area? What will you do if that exceed the limitation?
- Will you take into concern the environmental impact of port expansion project? Charge fines on port enterprises that impact the port ecosystem?

Is that all the port terminals are doing green port construction now? What are the challenges you have met? Such as technical issue, grants.

If the terminal operate are reluctant to implement green port strategy, what will the port do?

Q4 Which part in green port evaluation system is the weak point of our port? What are the challenges? Do you have short-term and long term future plan for the challenges?

I will ask: what challenge cannot be solved by port only and need help from other authority?

Q5 Road only transport modal is still the most popular way in container consolidate and distribute in Ningbo-Zhoushan port. It is one of the main reasons causing environmental impact (GHG emission, air emission, noise, congestion) in port area. To shift transportation modal to a greener one, what did Ningbo-Zhoushan port do? What the challenges?

- **Policy (incentives, cooperation with inland ports)**
- **Equipment (railway accessibility, capacity, availability)**
- **Support services (professional worker hiring, transport liability distribution, seamless connect in mode transfer)**

I will ask:

From policy angle:

- Does the port have incentive strategy for shippers using sea-rail modal? What do you think of this strategy?
- How many dry ports do Ningbo-Zhoushan port has now? and what is future investment plan geographically? What the relationship between Ningbo-Zhoushan port and its inland dry ports? How to guarantee the number of containers from them if the dry ports have several partners sea ports? Take cooperation between Ningbo-Zhoushan port and Wuhan port, how do they run the contract?
- If the one day, the port charging carbon tax on containers shipped by road only modal over long distance, to what extent do you think is a good way to popularizing intermodal transport?

From the equipment angle:

- Now in some terminals there are tracks connect directly with national rail network. Is the track in port area owned by Ningbo Port Company? Do all the containers in Ningbo-Zhoushan port has free accessibility to them?
- As there are differences between sea containers and China rail containers, cargo has

to be reloaded at terminal. Is the terminal that connected with track equipped with professional people and equipment? Are there any challenges in this part?

- Do the capacity of liner rail suitable for sea-rail business? How many containers can they carry each time? Can the length and number of containers carried each time be added?
- What is the timetable of liner rail now? What is the total transport time varies between road and rail? What can be done to cut the total time of railway (such as improve the speed of locomotive, reduce cargo handling time in port and dry port)? What are the challenges?
- In china, national network is not opened to private logistic companies or shippers, what will the port do to solve this problem (sign contract with China railway bureau)?

From service angle:

- Who will in charge of professional sea-rail intermodal transport workers in terminal and dry ports, the Ningbo Port Company, terminal operator or container terminal manager? Will that be a challenge?
- If in the future the timetable of liner changed, higher frequency and work load, who will in charge of the changes in terminal workers' working patterns?
- The cost of each sea-rail container is high, what is the price now? And what do you think is the competitive price for rail? In order to cut the cost and provide seamless service, there need an integrated logistics company to take whole responsibility in one contract but varies carrier. Is the Ningbo-Zhoushan port logistic company play this role? About the liability, what do you think need to be done and what policy incentive need to be published?

Q6 what is the geographic distribution of container sources in Ningbo hinterland? Are the transport modes consistent with their break-even distance (such as in China, road is 500km, railway is 500-2000km, waterway is >2000km)? If it is not compliance, what are the main contradictions?

Q7 from 'The Belt and The Road' initiative, 'Logistics Channel' planning to build Ningbo city as an important international shipping hub, we can see there are much

supporting policy to optimising collecting and distributing system in Ningbo-Zhoushan port. Do you think these initiatives meet the requirement of the port intermodal transport development? Which part need more strategy to enhance?

Research notes in Ningbo-Zhoushan port:

Question 1: about ship emission control, what tools have Ningbo-Zhoushan port adopted to mitigate GHG and air pollutant emissions? Such as pricing, monitoring and measuring, technical retrofit and market access control. What are the challenges in implementation, and how about the results? Could you use some examples to illustrate them?

Question 2: what about the market reaction to higher emission standards? Will it do harm to number of incoming vessels and the business of port? If do exist, what will the port do to face with these problems?

If the carrier or the ship owner reluctant to do ship retrofits, what will the port do to encourage them? Is there any legislation state council (such as bonus)? What do you think the best way to solve the problem?

Answers: The specific measures such as formulating the price for ship sewage water discharging activity and other activities related to environmental protection should be the responsibility of the Port Authority. The port companies are only responsible for implementation. The terminal charges are levied according to the charging standard formulated by the Ministry of Transport, which includes carbon emissions, environmental pollution and other service fee for ship. In China, the port operators have no right to commercially set standards and penalties for inbound fleets. This is the same situation in Dalian Port.

There are no incentives set by Ningbo-Zhoushan port company for environmentally friendly ships and inbound motor vehicles because the port does not have funds in this filed and has not received relevant policy support or subsidies. Besides, there is no special fund under the title of green port construction launched by port, most of financial supports

for these environmentally friend tools come from Environmental Protection and Energy Saving funds.

For the use of low-sulfur oil, the Ministry of Transport issued the ‘Plan for the Implementation of Ship Emission Control Areas in the Pearl River Delta, Yangtze River Delta, and Bohai Sea (Beijing-Tianjin-Hebei) Waters’, and set up the first air pollutant emission control area for ships. However, until today (September 2017) there is no enforcement, and it is not clear which government department is responsible for inspection. Terminals do not monitor ship emissions as this work belongs to other environmental protection department.

For the use of shore power, newly built ships are required to equip with shore power equipment, and newly built terminals are required to install shore power supply equipment in more than 50% berths. As for international container ships, the impact of equipment renovation to use on-shower power supply system is small, because the other countries they visited already asked or will ask the use of shore power as a mandatory measurement. However, the pressure on old domestic ships are quite heavy because of high costs.

Based on the experiences of terminal manager in Ningbo-Zhoushan, the difference between using shore power and burning fossil energy in price for international vessels is small. However, for bulk carriers is much bigger because of the fierce market competition and cheaper freight rates. Since there are no standard fees of using shore power for ships in China, it is necessary for the Maritime Safety Administration and the port and shipping bureau to jointly set the price for utilization. Therefore, the shore power has not been implemented in large scale even the terminal can provide shore power services.

On the other hand, there are technical boundaries in implementation of on-shore power supply system. China's electricity frequency is 50Hz, there is a high technical requirement for 60Hz used in international ships. The equipment retrofitting is a large investment for terminal. For domestic ships, the voltage frequency is the same, and the shore power can be used directly. However, since there is no mandatory policy, the terminal has no right to force the ship to do so.

Question 3: What have Ningbo-Zhoushan Port done to control emissions caused by port activities according to the guideline? What about the results of these tools? Could you illustrate with examples in terms of policy (strategy planning, specific grant, staff education), production (pollution control, waste reuse, energy saving and renewable and clean energy using), management (set specific people and project, environmental quality monitoring, restraints and incentives)

Answers: About control emissions and pollutant come from port activities, in 2008, under the corporate investment and government incentives, all gantry cranes have been converted into electricity powered. Container-operated cranes use electricity to achieve waste energy feedback, and the cost has been recovered within three years. The company invested in the replacement of lighting systems using energy-saving new LED lamps. The company's trucks in the port area are all using LNG energy now, also the port cooperates with gas company to provide natural gas installation services for their own fleets and inbound social fleets. As for energy conservation and emission reduction, the terminal will report its own results to apply for the relevant subsidies given from state and local government.

The terminal has already assigned specific person responsible for environmental protection supervision, and established a safety and security department to incorporate environmental protection duties into the scope of safety management. In the expansion of the terminal, the environmental evaluation about impact of the project on the ecological environment of the port area will be carried out before construction. Then the responsibility is taken by the assigned person during the project.

Ningbo-Zhoushan Port and China National Offshore Oil Corporation (CNOOC) have established a joint venture to jointly promote the natural gasification project of the truck fleet in the port. As of the end of July 2017, Ningbo Port had 1063 vehicles and 460 LNG vehicles, accounting for 43.27%. Every single LNG vehicle can reduce the emission index by 80% and the noise index by 40%. Compared with the old diesel vehicle, one LNG power truck runs for 10,000 kilometers could saving 3,500 yuan. The natural gas fleet is mainly used for 1) container transfer between terminals in the port district 2) haulage to

the ship 3) loading in port area shipped to the factor. All energy conservation and emission reduction projects can be applied for partial rewards after being reported to the relevant departments.

Question 4: Which part in green port evaluation system is the weak point of our port? What are the challenges? Do you have short-term and long term future plan for the challenges?

Answers: Ports' operator in China has to following the requirements setting by national and local Environmental Protection Administration. Basically all the tools for the items listed in Guideline for Green Port Rating System (Trial Implementation) (attached in appendices) such as waste management and recycling, including sewage, spills and ballast water, noise and vibration reduction in handling activities and dust control from bulk handling, ecosystem protection (marine habitat, wetland and coastal erosion) are implemented.

As for the weak point in Guideline for Green Port Rating System (Trial Implementation), Ningbo-Zhoushan port has not develop sustainable energy source for sustainable energy use in large-scale. Only some lighting signs use solar energy because it is small investments. And the terminal as a user of energy-saving lamps can receive subsidies from local government. For sustainable energy use, China national government has not yet issued policies to reward users.

The company will consider the use of sustainable energy in the future, but for wind energy, geothermal energy, and other renewable energy sources, these measures will not be considered in the near future owing to the large investment.

In addition, there is no clear training material for employees' environmental education yet, but from the company side, a shuttle bus is provided between the city center and the dock to reduce the number of private cars using in the port.

Question 5: To shift transportation modal to a greener one, what did Ningbo-Zhoushan port do? What the challenges?

Answers: For Q5, to shift transportation modal from road only to a greener one Ningbo-Zhoushan port has set up dry ports in hinterlands. This means the port company set up departments in hinterland cities to actively searching cargo flow from consigners or small logistics companies to let them use Ningbo-Zhoushan port instead of Shanghai or other competitor ports. In this case, the supply of cargo source could be guaranteed for using multimodal transportation in the next stage. This is the same in Dalian Port.

In terms of multimodal transport, the sea-rail combined transport and water-to-water transfer business are mainly carried out in Ningbo-Zhoushan port. The water-to-water transfer is composed of two parts. Internal branch transportation: the inland goods are transported by Ningbo Zhoushan Port to the foreign ports and the foreign port goods are transported to the mainland by Ningbo Zhoushan Port. International transfer: foreign ports to Ningbo Zhoushan Port are shipped to another foreign port. Sea-rail combined transport refers to: the goods arrive at Ningbo Zhoushan Port (both domestic and foreign ports) by waterway, and then transported by rail to the mainland. Or transport in the opposite direction.

In terms of pricing method, firstly, logistics companies that operate sea-rail intermodal transported containers could apply subsidized from Ningbo Government. It has to be re-applied every 3 years and decrease year by year. Secondly, the shipping company is encouraged to give priority to sea-rail intermodal transported containers such as preferential treatment on shipping space and the usage time. Thirdly, the sea-rail intermodal transported container could get concessions in port rates. For example, heavy containers are exempt from transfer fees, late fees, amendment fee, and empty container storage fees. There are discounts on loading and unloading fees and heavy container management fees as well.

Even sea-rail intermodal transported container has subsidies from three part, there are some difficulties for Ningbo-Zhoushan port promote the modal transfer. In the sea-rail transportation, the container goods come from inside Zhejiang Province constitute large

proportion, reaching 60%-70%, mainly from Shaoxing, Hangzhou, Jinhua, Yiwu, Zhangzhou, Taizhou, Huzhou, Lanxi. Because short-distance railway transportation (within 300km) has no obvious price advantage against the road transportation, it is difficult to operate the modal shift from road to railway owing to high transportation cost for consigner. In addition, railways have poor timeliness when compared with highways. For more urgent goods, the consigner will still choose road transport.

In term of equipment: The port company is promoting the construction of railway passages and inbound railway lines. From Beilun Station (National Railway Station) to Beilun Port Station (Port's own station), some railways and locomotives are owned by Ningbo Zhoushan Port. Currently, there are 4 railway wagons with a total of 102 carriages. The railway terminal owned by the Port Company has large container handling compacity. Beilun Port Sea-rail Intermodal Station has an annual handling capacity of 350,000 TEUs, Zhenhai Station will be upgraded from 200,000 TEUs to 430,000 TEUs once put into use in November 2017, and 600,000 TEUs for Chuanshan Port Station (expected to be completed in 2019). After completion, Ningbo Port is expected to handle 1.58 million TEU of sea-rail combined transport containers by 2020.

Question 6: what is the geographic distribution of container sources in Ningbo hinterland? Are the transport modes consistent with their break-even distance? If it is not compliance, what are the main contradictions?

Answers: following table shows the subsidies for sea-rail intermodal containers' shipper from Ningbo City Council in 2012. It can be noticed that Ningbo City Council subsidize most is the container send to and from over 2000 kilometres. The band of distance and subsidy are not equally spaced. Subsidy gap between band 'within 400' and '400 to 1000' is largest. This may because of the container's railway freight price lost its advantages over short distance (less than 400km). Therefore, the break-even distance in Ningbo-Zhoushan port is around 300 to 400km.

Subsidies for sea-rail intermodal containers' shipper from Ningbo City Council in 2012. (Collected from interviewee)

Transportation distance (in kilometre)	Subsidy (CNY per TEU)
Within 400	200
400 to 1000	500
1000 to 2000	600
Over 2000	800

Question 7: Do you think these initiatives meet the requirement of the port intermodal transport development? Which part need more strategy to enhance?

Answers: The response on ‘Which part need more strategy to enhance?’ is about China's railway system. China's railway network is far from being developed and less convenient than road network. In the inland areas, the supporting facilities of the railway container yards are behindhand. The insufficient cargo handling capacity of railway terminal hamper sea-rail intermodal transportation

In addition, high railway freight rates if another obstacle. It is hard to get competitive freight rate by port company without government support.

Moreover, owing to customer habits in cooperation with the Shanghai port or other competitor ports has been formed for a long time, also because the freight rates of Ningbo-Zhoushan Port and Shanghai Port are not much different, the cargo supply from overlapping hinterlands is less and the effect of dry port is not good.

Material collected during the interview in Ningbo-Zhoushan Port:

At present, the annual import volume of Zhejiang Province is about 1.82 million TEU, of which 1.12 million TEU is imported from Ningbo Port, accounting for 62% of the total. From the perspective of the provinces and cities across the province, Ningbo, Wenzhou and Taizhou are the traditional import sources of the Zhoushan Port in Ningbo, and more than 80% of the imported goods are imported from Ningbo Port. In addition, through a series of fruitful source development work, the proportion of imported goods from Ningbo and Shaoxing to Ningbo Port has increased in recent years, reaching 70% and 65% respectively. However, in the northern Zhejiang region, such as Hangzhou and

Huzhou, the proportion of imports is not obvious, only 35% and 20%. Under the influence of traditional trade habits, the above regions still basically choose Shanghai as the entry port for their imported goods.

At present, Zhejiang's annual export volume is about 9.6 million TEU, of which 6.1 million TEU is exported from Ningbo Port, accounting for about 63% of the total. From the perspective of the provinces and cities across the province, Ningbo, Jinhua, Taizhou and other places are the traditional export source hinterland of Ningbo Zhoushan Port, and more than 80% of the export goods are exported from Ningbo Port. In addition, the proportion of export goods in Ningbo Port in Ningbo has increased in recent years, reaching more than 60%. The proportion of Jiaying and Huzhou in the northern Zhejiang province is the lowest, only 15%.

The mode of port collection in the province is mainly based on road transportation, supplemented by railway and waterway transportation modes (intra-branch and internal trade lines).

The outer hinterland of Ningbo Zhoushan Port spans the east, middle and west of China, and the provinces include Jiangxi, Anhui, Jiangsu, Hubei, Hunan, Henan, Sichuan, Chongqing and Xinjiang. In 2015, the amount of goods supplied outside the province through Ningbo Zhoushan Port reached 250,000 TEU. The port-gathering mode of the province's external sources of goods is mainly based on railway and waterway transportation modes (internal and domestic trade lines).

Although the container throughput of Ningbo Zhoushan Port has been among the highest in the world, 40% of the province's supply is lost from other ports. The supply of goods outside the province and the international transfer capacity are far lag behind than Shanghai Port. There are several reasons for this:

Differences in the industrial structure of the hinterland.

Ningbo is an export-oriented industrial economic city. The industrial structure is dominated by heavy chemical industry. The industrial characteristics of Ningbo are very different from those of Shanghai and southern Jiangsu. In particular, the proportion of

manufacturing bases of multinational enterprises is too small. As in the hinterland of the harbour and surrounding areas, there are manufacturing bases of multinational corporations and matching professional markets. From the perspective of logistics cost, they will choose the nearest port.

Market channels and customer inertia.

Once the market channel is established, the customer's choice will generally form inertia, and it is generally difficult to change. In terms of geographical location, Shanghai Port and Ningbo Zhoushan Port have large economic hinterland superimposed areas, such as Zhejiang North and Hangzhou Xiaoshao in Zhejiang Province, such as Sunan and Anwei. Customers in these areas have strong selectivity in terms of ports. As Shanghai Port is ahead of Ningbo Port in terms of route layout, customers have become accustomed to the import channel of Shanghai Port. In the case of little difference in logistics costs, Shanghai has a large number of customers who choose to take the initiative. Therefore, Shanghai Port has a stronger set. Product capacity.

In terms of international trade, foreign suppliers are often in a dominant position. Due to the high world influence of Shanghai Port, foreign suppliers have taken the initiative to choose Shanghai. At the same time, due to the establishment of a large international trader's headquarters in Shanghai and the mature trade market that Shanghai has formed, Shanghai Port has a unique customer source advantage.

The development of multimodal transport business lags behind.

Ningbo Zhoushan Port has long relied mainly on water, water and highway collection and transportation. The development of container sea-rail combined transport and Haihe intermodal transportation started late. The proportion of business volume in port container throughput is much lower than that of developed countries, and lower than other coastal areas in China. Brother port. The mode of transportation is too single to weaken the comprehensive ability of the hinterland.

Research notes in Dalian port:

Question 1: about ship emission control, what tools have Dalian port adopted to mitigate GHG and air pollutant emissions? Such as pricing, monitoring and

measuring, technical retrofit and market access control. What are the challenges in implementation, and how about the results? Could you use some examples to illustrate them?

Question 2: what about the market reaction to higher emission standards? Will it do harm to number of incoming vessels and the business of port? If do exist, what will the port do to face with these problems?

If the carrier or the ship owner reluctant to do ship retrofits, what will the port do to encourage them? Is there any legislation state council (such as bonus)? What do you think the best way to solve the problem?

Answers: The Marine Department will inspect the ship's oil record book to supervise if they are using low-sulphur oil. However, this is now in a transitional phase and is using education method to ships that do not use low-sulfur oil. The specific enforcement measures and the consequences of the violations have not been determined yet. And this applies not only in Dalian Port but also Ningbo-Zhoushan Port as well.

The implementation situation of other green port tools on ship emission control in Dalian port are same as Ningbo-Zhoushan port. No 'penalty or incentive based on green performance of vessels (e.g. ESI, EEDI)' nor 'Require slow steaming while on approach or in the port'. For on-shower power supply system, Dalian met similar obstacles as Ningbo which are commonly exist among Chinese vessels and ports according to response from interviewees.

Question 3: What have Dalian Port done to control emissions caused by port activities according to the guideline? What about the results of these tools? Could you illustrate with examples in terms of policy (strategy planning, specific grant, staff education), production (pollution control, waste reuse, energy saving and renewable and clean energy using), management (set specific people and project, environmental quality monitoring, restraints and incentives)

Answers: Similar to Ningbo-Zhoushan Port, the production processes of Dalian Port have to follow the requirements set by national and local Environmental Protection Administration. Basically all the tools for the items listed in Guideline for Green Port Rating System (Trial Implementation) (attached in appendices) such as waste management and recycling, including sewage, spills and ballast water, noise and vibration reduction in handling activities and dust control from bulk handling, ecosystem protection (marine habitat, wetland and coastal erosion) are implemented.

About control emissions and pollutants come from port activities (Q3), The cargo handling equipment in Dalian Port area has not been fully electrified, and some terminals still use diesel bridge cranes. Basically because of the cost of retrofitting the old terminals is very high. Now there are fewer LNG vehicles in the port area, as the cost of the port's own motorcade is high. This is because of the route from Dalian Port to its hinterlands mostly in rugged areas therefore it is difficult to carry heavy cargo by LNG trucks owing to technical barriers. The engine Start Up Power is not enough to support at some road sections.

Question 4: Which part in green port evaluation system is the weak point of our port? What are the challenges? Do you have short-term and long term future plan for the challenges?

Answers: interviewee in Dalian port did not give exact information on this question.

Question 5: To shift transportation modal to a greener one, what did Ningbo-Zhoushan port do? What the challenges?

Answers: To shift transportation modal from road only to a greener one, Dalian Port Company has invested in developing railway track and terminal in the port area. Dalian Port Hub has the total area of railway container work stations is 1.1 million square meters, and the capacity of container trains reaches 950,000 TEUs/year. In 2010, the Dalian Railway Container Central Station was put into use which was jointly built by Dalian Port and China Railway Group. The total investment of the project is 712 million yuan, covering

an area of about 1743 acres, only 1 kilometer from the front of the terminal and has an annual working capacity exceeds 200,000 TEU.

Dalian Port is vigorously promoting the construction of multi-modal transport in the Asia-Pacific-Northeast region, and accelerating the construction of inland hub stations and network of trains through various modes such as independent investment, leasing operations and business cooperation. Among them, the Shenyang East Inland Port, established in 2003, is the inland port with the largest sea-rail combined transport capacity in China, with an annual operating capacity of more than 100,000 TEU. Shenyang, Changchun, Harbin and Tongliao are 4 major sea-rail intermodal transportation centers of Dalian Port. Now there are more than 70 block trains running on 37 block train lines every week.

Question 6: what is the geographic distribution of container sources in Ningbo hinterland? Are the transport modes consistent with their break-even distance? If it is not compliance, what are the main contradictions?

Answers: the interviewee did not give exact number of the break-even distance.

Question 7: Do you think these initiatives meet the requirement of the port intermodal transport development? Which part need more strategy to enhance?

Answers: Dalian Port Company has developed its own container control system therefore could save the costs. In addition, the Company also give subsidizes to the sea-rail transported container (did not give detailed number). But according to the interviewee there is no financial subsidize for these containers from the state or local government. This will add on the financial burden of Dalian Port. The Port Company also invested in the railway terminal and track construction in the port area however the cooperation with the national railway was not smooth, which made Dalian Port cannot get competitive freight prices than Yingkou Port. The cooperation between Yingkou Port and Shenyang Railway Bureau has reduced the cost of railway freight from northern city to Yingkou Port and split the source of supply.

However, there are some threatens. Dalian Port has not finished the integration with adjacent ports in Liaoning Province and the biggest competitor is Yingkou Port. The distance between two ports is less than 200 kilometre while Yingkou Port is closer to the mainland. The geographical location of Dalian Port has its limitation, most of cargo flow come from north and south. Therefore, once the cargo artery is catching by Yingkou Port then Dalian Port will in a weak position.

In addition, government sometime intervene the management of port terminal. Some foreign shipping company invested in the construction of terminal but may unprofitable owing to pressure from local government and this eventually led to the divestment. The competition between the terminals was fierce and has serious repeated construction.

Material collected during the interview at Dalian Port:

The Dalian Port Railway Hub has a reasonable layout and perfect functions. The MTR directly extends to the forefront of the terminal to achieve seamless integration of hot metal work. The container port area now has 18 railway lines with a total length of 16,000 meters and a distance of 500 meters from the front edge of the terminal. The total area of railway container work stations is 1.1 million square meters, and the capacity of container trains reaches 950,000 TEUs/year. In 2010, the Dalian Railway Container Central Station, which was jointly built by Dalian Port and China Railway Group, was put into use. The total investment of the project is 712 million yuan, covering an area of about 1743 acres, only 1 kilometer from the front of the terminal. It is the only connection with the port in China. At the station in front of the port, the annual working capacity exceeds 200,000 TEU.

The train service network is gradually improved. Relying on the rich network of domestic and foreign trade routes, Dalian Port is vigorously promoting the construction of multi-modal transport in the Asia-Pacific-Northeast region, and accelerating the construction of inland hub stations and network of trains through various modes such as independent investment, leasing operations and business cooperation. Among them, the Shenyang East Inland Port, established in 2003, is the inland port with the largest sea-rail combined transport capacity in China, with an annual operating capacity of more than 100,000 TEU. At present, Dalian Port has initially completed the inland layout of '4 major centers, 12

stations and 31 stations' with Shenyang, Changchun, Harbin and Tongliao as the core; 37 lines have been opened, which are stable every week. Run more than 70 classes.

The main cargo categories of Dalian Port and Sea Rail Transport are food and grain deep processing products, automobiles and spare parts, chemicals, wood products, waste paper and pulp, glass, mineral water and other suitable containers. In 2016, the number of sea-rail intermodal containers was 406,000 TEUs, a year-on-year increase of 16.6%. From January to July 2017, 249,000 TEUs were completed, a year-on-year increase of 15%, and continued to maintain a good momentum of rapid growth.

Rapid development of the international logistics channel construction.

In March 2015, the three ministries and commissions jointly issued the "Vision and Action for Promoting the Construction of the Silk Road Economic Belt and the 21st Century Maritime Silk Road". Dalian Port is the only port in the Northeast that is included in the "One Belt, One Road" master plan. In October 2016, the National Development and Reform Commission issued the "China-European Train Construction and Development Plan (2016-2020)", which also positioned Dalian Port as an important node for the construction of the China-European train.

Since the opening of the first Sino-European class in July 2013, Dalian Port has actively seized the development opportunities of the "Belt and Road" construction and established close cooperative relations with key enterprises such as Russia Railway, Germany Railway, China Railway General Corporation and COSCO Shipping. Create a public platform and service brand for transit trains with Dalian Port as the core. In November 2015, Dalian Port and the German National Railway Company signed a strategic cooperation agreement with Sweden in the Sino-European Union, which became the only cooperative port of the German Railway in the Northeast. In January 2017, Dalian Port and Russia Railway Container Co., Ltd. signed a memorandum of strategic cooperation. The two sides established a long-term strategic partnership to jointly promote the effective connection between the Russian railway and Dalian Port and Sea Rail, and achieve mutual benefit and win-win development.

At present, Dalian Port has a total of 5 lines in Central Europe. The goods going abroad mainly come from East China, North China, Southeast Coast, Japan, South Korea and Southeast Asian countries. The goods include electronic products, daily goods, equipment, automobiles, building materials, etc. The return goods are mainly resource products produced in central Russia. Such as logs, plates, pulp, etc. In 2016, Dalian Port completed 18,000 TEUs of transit containers, an increase of 106% year-on-year; in January-July 2017, the number of transit containers was 16,000 TEUs, an increase of 179%.

In the absence of government subsidies, Dalian Port takes the market-oriented operation as the core and gives full play to the advantageous resources of the port comprehensive service system, further expanding the Dalian port service function and its comprehensive influence in the Northeast Asian economic circle. At the same time, with the construction of international logistics channel as the starting point, Dalian Port vigorously develops specialized logistics such as automobile, timber and cold chain. Through the two-way driving of industry and logistics, it will drive the accumulation of industrial factor resources in Dalian and promote the revitalization, transformation and upgrading of the old industrial base in Northeast China.

Near future plan:

Dalian Port is going to firstly consolidate and strengthen the construction of multimodal transport service system.

During the ‘13th Five-Year Plan’ period, Dalian Port will revitalize the old industrial bases in Northeast China in accordance with the “Notice on Further Encouraging Multimodal Transport Work” jointly issued by 18 ministries and commissions such as the Ministry of Transport, and further deepen the relationship with Shen and Ha. The bureau's all-round strategic cooperation achieves strategic transformation and development through technological equipment innovation, logistics model innovation, strengthening management, reducing costs and increasing efficiency. The next step is to strengthen process optimization and business innovation, strengthen cost management and control, and reduce overall costs and expenses. Second, we must improve the organization and delivery mode of the train, improve convenience and timeliness, and thus guide the

transfer of foreign trade sources from roads to classes. The column is shipped. Third, on the basis of stable operation of inland hubs such as Shenyang and Tongliao, continue to increase the construction and transformation of inland ports, and invest in special facilities such as front hoists and trailers to further improve the level of inland container operations and services. ability.

Secondly, strengthen the development of supply sources in the China-European market, and optimize the structure of the source of supply.

In the next step, Dalian Port will give full play to the advantages of the route service network, deepen the supply of goods in South Korea, Japan, Southeast Asia and the southeast coastal market, increase the development of international transit sources, create differentiated Sino-European train products, and shape the Dalian Port China-Europe class. service brand.

On the basis of the development of the source of the voyage, Dalian Port will also focus on strengthening the development of Russian imported wood, pulp and European imported auto parts, high-end consumer goods and other return sources, further optimizing the round-trip source structure and reducing empty container transportation. Reduce overall operating costs.

Thirdly, improve the sea-rail combined transport service system and promote the rapid development of special logistics such as cold chain and automobile.

In accordance with the overall requirements for the transformation and upgrading of port enterprises, upgrading quality and efficiency, Dalian Port will actively promote the coordinated development of domestic and foreign sea-rail combined transport business, achieve both quantity and efficiency, improve the organization and delivery mode, improve convenience and timeliness, and guide Dalian. Hong Kong's foreign trade sources were transferred to the queue for shipment. To this end, on the one hand, we must further improve the construction of the sea-rail combined transport service system, and build a sea-rail combined transport platform, a shipping booking platform, a financial trading platform, an information service platform and a card gathering alliance. On the

other hand, it will further strengthen the development of special logistics such as cold chain, automobile and timber, and expand the integration mode of logistics, trade, finance and information through the organic combination of port service functions and key industries to realize the transformation of new and old kinetic energy of port development. Dalian Port has become an important carrier for the integration and development of modern high-end service functions, and has fully assisted the construction of Dalian shipping center, logistics center, trade center and financial center.

Support needs:

The Railway container pricing mechanism needs to be improved.

In order to promote the development of sea-rail combined transport, the railway department has given preferential downward policies to container trains. However, due to the short-term transportation links at both ends, the door-to-door price of the whole process still has a large gap compared with road trailers. Since 2017, the Harbin Railway Bureau and the Shenyang Railway Bureau have strictly controlled the downward movement of railway containers. According to the calculation of the air return to the intermodal mode, the freight rate of the Changchun regional railway increased by nearly 1,500 yuan/car compared with 2016, and the Harbin area rose by about 2,200 yuan/car, further weakening the competitive advantage of the container sea-rail combined transport. In order to effectively improve the competitiveness of the highway, it is recommended that the railway department set up a more flexible pricing mechanism for the truck market in the standard road, and at the same time liberalize the restrictions on the size of the cabinet and the name, and cultivate the sea-rail combined transport market.

The China-European support policy has not yet formed a joint force.

At present, the state has not yet issued specific support and guidance policies for the development of China-European trains. The support policies of trade, transportation, railways, shipping and other parties have not yet formed a joint force. In addition, various local governments in China have issued financial support policies, which has made the

market expansion of China-European trains in a disorderly state, and it is difficult to establish a market structure with complementary advantages and clear division of labor. In order to give full play to the leading role and leading role of Dalian International Shipping Center, it is recommended to build the “Liaoman Europe” channel of Dalian Port into the main channel of “One Belt and One Road” in Northeast China, accelerate the support policies of port environment and special funds, and guide local governments. Policy funds are invested to form a sustainable development pattern that is consistent with market rules.

Refrigeration train service system needs to be improved.

The cold storage train business is still in its infancy, the operation mode has yet to be tested and perfected, and the cold chain brand needs to strengthen its publicity. Therefore, it is necessary to complete the market cultivation as soon as possible and improve the supply organization capacity. Due to the fact that the refrigeration policy has not yet established a definite standard, the freight rate is higher than that of road transport, and the competitive advantage is not obvious. At the same time, the volume of shipments of refrigerated trains is large and the arrival time is concentrated. The consignee often cannot pick up and unload all the goods at one time. Therefore, it is necessary to provide reefer storage and plug-in services at the inland railway terminals.

Informatization and standardization need to be improved.

Due to the large number of countries along the Central European class and the long service chain, and the formation of unified operations, services, documents, and information standards, the information asymmetry between the various links is more serious, increasing communication and coordination costs. It is not conducive to the whole process of logistics management and operation, and also limits the improvement of the quality of operation services. To this end, it is recommended that the state carry out top-level design from a strategic level, set up a special department, and establish relevant standards and norms for multimodal transport.

Guideline for Green Port Rating System (Trial Implementation)

Item	Full marks	Content	Full marks	Indicators	Full marks	Checklist and marks
Idea	100	Strategy	55	Strategy planning	20 (hierarchical)	<ul style="list-style-type: none"> • Publish the GDSP publicly (16~20) • Publish the GDSP only internally (11~15) • Only draw up the GDSP (5~10)
				Special founds	20 (hierarchical)	<ul style="list-style-type: none"> • Settled budget for performing GDSP (11~20) • Only temporary capital for GDSP (5~10)
				Working plan	15 (accumulated)	<ul style="list-style-type: none"> a) Shown the GDSP in operator strategy (3~5) b) Arrange the GDSP mission in port developing plan (3~5) c) Arrange the GDSP in annual working program (3~5)
		Culture	45	Corporate culture	20 (accumulated)	<ul style="list-style-type: none"> a) Release the Annual Green Port Development Report (7~10) b) Integrate the Green Port theory into enterprise management system (3~5) c) Fulfil its social responsibility to build green port image (3~5)
				Education and training	15 (accumulated)	<ul style="list-style-type: none"> a) Has the education and training plan for Green Port construction (3~5) b) Organize education and training program regularly (3~5) c) Arrange professional skill training regularly (3~5) d) Precipitate in every kind of education and training activities positively (1~2)
				Propaganda activities	10 (accumulated)	<ul style="list-style-type: none"> a) Has the plan for Green Port publicity program (3~5) b) Carry out the publicity program (3~5)
GDSP: Green Development Special Planning The fluctuation of score behind each item in checklist depend on the degree of performance						

Assessment for specialized container terminal:

Item	Full marks	Content	Full marks	Indicators	Full marks	Checklist
Action	100		35	Pollution control	20	a) Using non-traditional water source for flushing, afforest, road spraying, car washing and cooling... b) Using the water-saving equipment that currently encouraged by the government c) Using highly efficient irrigation technique such as sprinkling/ micro-irrigation system d) Collecting and disposing toxic and harmful residue separately, send the dangerous garbage to qualified institution to deal with e) Take the noise reduction measures such as acoustic screen f) Formulate Environmental Pollution Emergency Management Plan and equipped with emergency handling equipment (Meet 6 and more conditions: 17~20; Meet 5 conditions: 13~16; Meet 4 conditions: 10~12; Meet 3 conditions: 7~9; Meet 2 conditions: 4~6; Meet 1 conditions: 1~3; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)
				Comprehensive utilization	10	a) Deep decontaminate and recycle the wastewater b) Take the measure for Reusing the dredging sediment and other solid waste (Meet 2 or more conditions: 6~10; Meet 1 conditions: 1~5; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)

			Eco-environment protection	5	<ul style="list-style-type: none"> a) Take part in surrounding eco-environment protection activities b) Take the measure to protect wharf's fore water eco-system c) Afforest the harbor district (Meet 3 or more conditions: 3~5; Meet 2 conditions: 1~2; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)
		Energy conservation	Machinery equipment	15	<ul style="list-style-type: none"> a) The diesel engine of container rubber-tired gantry crane could control the revolving speed according to the load b) Using potential energy recovery or super capacitor technique in crane c) Crane are powered by variable frequency or DC drive technology (Meet 3 or more conditions: 11~15; Meet 2 conditions: 6~10; Meet 1 conditions: 1~5; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)
			Operation technics	20	<ul style="list-style-type: none"> a) Adopting the resource and equipment scheduling technics in full port area b) Using container tractor which applying 'one drag multi hung' transport mode c) Using rail-mounted gantry container cranes in work d) Employing straight charging and direct discharging cargo handling technique (Meet 4 or more conditions: 16~20; Meet 3 conditions: 11~15; Meet 2 conditions: 5~10; Meet 1 conditions: 1~4; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)
			Auxiliary facility	15	<ul style="list-style-type: none"> a) Equip the facility providing on-shore electricity for ship in dock b) Employing the grid harmonic control and reactive compensation

						<p>technology</p> <p>c) The electricity substation using energy-saving voltage transformer</p> <p>d) Intelligent control technology is adopted for outdoor lighting</p> <p>e) Adopt energy-saving lamps and lighting systems</p> <p>f) Using waste heat for heating system</p> <p>g) Employing the air conditioner that energy efficiency rating at level 1 (Meet 7 and more conditions: 13~15; Meet 6 conditions: 11~14; Meet 5 conditions: 9~10; Meet 4 conditions: 7~8; Meet 3 conditions: 5~6; Meet 2 conditions: 3~4; Meet 1 conditions: 1~2; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)</p>
		Low-carbon	15	Fuel substitute	10	<p>a) The container rubber-tired gantry crane employing the technology that electricity instead of oil</p> <p>b) Using LNG or electric powered vehicles in port</p> <p>c) Using LNG or electric powered mechanical or horizontal transport vehicles</p> <p>(Meet 3 and more conditions: 7~10; Meet 2 conditions: 4~6; Meet 1 conditions: 1~3; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)</p>
				Renewable energy	5	<p>a) Employing ground source, seawater or air-source heat pump technology</p> <p>b) Employing solar energy, wind energy or other renewable energy sources</p> <p>Meet 2 and more conditions: 3~5; Meet 1 conditions: 1~2; Adopt every one other measure reaching the similar idea results, once approved, seen as meet 1 conditions)</p>
<p>Note: condition that does not meet the requirement ca not get points.</p>						

Items in checklist that do not fit the evaluated object, the number that required to meet in scoring rubric should be cut down accordingly.

Item	Content	Full marks	Indicators	Full marks	Scoring method
Management	System	30	Management organization	10 (accumulated)	a) Specify the department for Green Port construction (3~5) b) Specify the administrative staff for Green Port development (3~5)
			Audit and assurance	20	a) An energy audit has been carried out in the past 3 years (5~10) b) Start the environmental management system certification (ISO4001) work (5~10)
	Institution	70	Objective assessment	15	a) Undertake energy-saving and environmental protecting assessment of person in charge at all levels (3~5) b) Undertake the objective assessment in working team (3~5) c) Undertake the objective assessment in operators (3~5)
			Statistical monitoring	45	a) Monitoring the environment quality and pollutants' discharging process (10~15) b) Establish information system for environment management (10~15) c) Establish information system for energy

					efficiency management (7~10) d) Measuring the balance between energy input and output regularly (3~5)
			Incentive and constraint	10	a) Form internal incentive and restraint mechanism in Green Port construction enterprise (3~5) b) Form incentive and restraint mechanism for Green Port construction stakeholders (3~5)
Note: condition that does not meet the requirement cannot get points.					

Item	Full marks	Content	Full marks	Indicators	Full marks	Scoring method
Effectiveness	100	Efficiency	40	Eco-system	20	a) Annual air pollutant emission per unit throughput decrease 4.4% or more can earn 8, nul points for non-qualified. b) Annual COD (Chemical Oxygen Demand) emission per unit throughput decrease 4.4% or more can earn 8, nul points for non-qualified. c) Annual utilization rate of solid waste increased by 0.9% or higher earn 2, nul points for non-qualified. d) Ratio of port greening area in all possible afforested area increased by 2.0% and higher annually earn 2, nul points for non-qualified.
				Low-carbon energy	20	a) Port annual comprehensive energy consumption per unit product decreasing 0.8% or more get 12, nul points for non-qualified. b) CO2 emission per unit throughput decreasing 1.0% or more

						<p>earn 3, nul points for non-qualified.</p> <p>c) Annual fuel consumption accounts for total energy consumption decreasing 1.0% or more get 3, nul points for non-qualified.</p> <p>d) Annual renewable energy consumption accounts for total energy consumption increasing 4.1% or more get 2, nul points for non-qualified.</p>
		Ability	60	Eco-system	30	<p>a) Concentration of main air pollutant emission $\leq C_m$ get 12; $> C_0$ nul points.</p> <p>b) Concentration of COD emission $\leq C_m$ get 12; $> C_0$ nul points.</p> <p>c) Utilization of nontraditional water source $\geq 30\%$ get 4; $< 10\%$ nul points.</p> <p>d) Ratio of port greening area in all possible afforested area $\geq 90\%$ get 2, $< 85\%$ nul points.</p>
				Low-carbon energy	30	<p>a) Port annual comprehensive energy consumption per unit product $\leq E_1$ get 20, $> E_2$ nul points.</p> <p>b) CO2 emission per unit throughput $\leq C_1$ get 10; $> C_2$ nul points.</p>

Notes:

- a) Annual changes (range that decrease or increase) is the 2-year's average changing range before assessing.
- b) Value of C_m, C_0 can be found in local Air pollutant emission standards. E_1, E_2 and the fuels' caloric value can be found in appendix A, B and C.
- c) Emission of CO2= consumption quantity of fuel \times CO2 emission coefficient \times average low caloric value of the fuel

